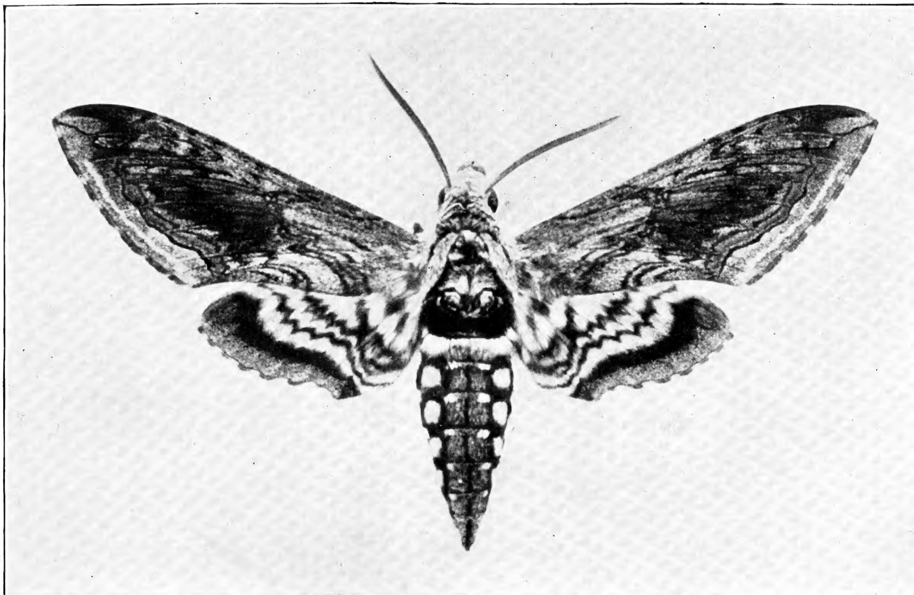

Northern Tobacco-worm Moth (*Protoparce celeus*).

[*Frontispiece.*]

INSECTS INJURIOUS TO STAPLE CROPS.

BY

E. DWIGHT SANDERSON, B.S.Agr.,

ENTOMOLOGIST, DELAWARE COLLEGE AGRICULTURAL EXPERIMENT STATION;
ASSOCIATE PROFESSOR OF ZOOLOGY, DELAWARE COLLEGE.

FIRST EDITION.

FIRST THOUSAND.

NEW YORK:
JOHN WILEY & SONS.
LONDON: CHAPMAN & HALL, LIMITED.
1902.

ROBERT DRUMMOND, PRINTER, NEW YORK.

PREFACE.

The sources of information concerning the insects affecting our staple crops are widely scattered throughout the bulletins of the State Agricultural Experiment Stations and of the United States Department of Agriculture, a few books on Economic Entomology, and various other publications. Few men but the entomologist have the desire or ability to glean an account of any given insect from the first-mentioned publications, if they know of the existence of others than those published by their own State station. The few books which have been written upon American Economic Entomology usually give but a brief and summary account of any given insect, too brief—it seems to the writer—to give a very clear understanding of the matter.

In preparing the following pages the author has been more and more impressed by the fact that for the control of most of the worst insect pests of our staple crops, the farmer must depend very largely upon general methods of farm practice. This being the case, it is essential that he have a correct knowledge of the pest to be combated; such a knowledge of its life-history as will make plain the reason for the effect of any given procedure against it. Thus the better class of farmers may find a work in which each

insect is treated somewhat comprehensively as to life-history, habits, and remedies, yet without being exhaustive or technical, to be of considerable service to them. To furnish such a guide to the more intelligent class of practical farmers has been the aim of the writer, who trusts that the following pages will be read as such and not as in any way a contribution to science.

The author wishes most unreservedly to disclaim any originality for the contents of the work, and to state that unless otherwise noted all the facts are merely compiled from the writings of others. Free use has been made of the writings of all the most prominent American entomologists. Where the treatment of a group of insects has been largely drawn from one or two sources, they will often be indicated by quotations in the text.

Many of the following chapters or parts of them have previously appeared in various agricultural journals during the past three or four years, to the editors of which the author desires to express his thanks for their courtesy in allowing him to here republish them; namely, The Country Gentleman, The Farmers' Review, Farm and Fireside, Farm News, The National Rural, Texas Farm and Ranch, The American Agriculturist, The National Stockman and Farmer, and The Practical Farmer.

The author is particularly indebted to Prof. M. V. Slingerland, of Cornell University, for kindly reading portions of the manuscript and for several suggestions of value; to Dr. L. O. Howard for assistance in part of Chapter X; and to his wife, Anna Cecilia Sanderson, for a large amount of clerical assistance.

E. DWIGHT SANDERSON.

NEWARK, DEL., February, 1901.

SOURCES OF ILLUSTRATIONS.

ELECTROTYPES of the following figures were purchased, being secured through the kindness of the parties named: Fig. 9, from Houghton, Mifflin & Co.; Fig. 102, from the Iowa Ag. Exp. Sta., through Prof. H. E. Summers; Figs. 7, 136, and 137, from Dr. J. B. Smith; Figs. 51, 52, 60, 84, and 85, from Cornell Univ. Ag. Exp. Sta., through Prof. M. V. Slingerland; Figs. 25 and 28, from The Farmers' Review, Chicago; Figs. 74, 75, 76, 77, and 78, from Dr. S. A. Forbes; Figs. 71 and 72, from The Country Gentleman, for which they were originally redrawn by the author; Fig. 53, from the Nebr. Agr. Exp. Sta., through Prof. L. Bruner; and Figs. 11, 24, 31, 50, 59, 61, 62, 64, 66, 67, 68, 79, 80, 81, 82, 83, 88, 89, 90, 91, 92, 93, 94, 97, 104, 105, 106, 107, 108, 109, 111, 112, 113, 114, 116, 117, 118, 119, 120, 121, 122, 123, 124, 126, 127, 128, 129, 131, 134, 135, 136, 143, 146, 154, 155, 156, 157, 158, 159, 160, 161, 162, from the United States Department of Agriculture, through the kindness of Dr. L. O. Howard and Mr. F. H. Chittenden, of the Division of Entomology and the Division of Publications, to which gentlemen we are under especial obligation.

The following figures were kindly loaned by the parties named: Figs. 29, 30, 32, 33, 34, 35, 36, 37, 38, 39, 40,

41, 42, 44, 45, 46, 47, 48, 110, and 150, from the Md. Agr. Exp. Sta., through Prof. A. L. Quaintance, these having been first used by the author in The Farmers' Review; Figs. 65, 132, and 133, from the Ky. Agr. Exp. Sta., through Prof. H. Garman; Fig. 125, from the Fla. Agr. Exp. Sta., through Prof. H. A. Gossard; Figs. 54, 55, 56, 57, 58, 63, 70, 96, 98, 101, and 103, from the Ohio Agr. Exp. Sta., through Prof. F. M. Webster; Fig. 49, from the Minn. Agr. Exp. Sta., through Director W. M. Liggett; Figs. 12 and 95, from the Del. Coll. Agr. Exp. Sta.; Fig. 151, from the Peninsula Horticultural Society, through Prof. Wesley Webb.

Figs. 19, 20, 21, 66, 138, 139, 140, 141, 144, and 147 were loaned by the author. Figs. 13, 14, 15, 16, 17, 18, 23, 26, 27, 99, 115, 145, 149, 152, and 153 were copied from prints. Figs. 1, 4, 5, 6, 8, and 10, and Figs. 2, 3, 22, 86, 87, and 100 and frontispiece are original from photos by the author, the photos of the latter numbers being loaned by the Del. Coll. Agr. Exp. Sta.

TABLE OF CONTENTS.

CHAPTER IX.

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

CHAPTER XIII.

CHAPTER XIV.

CHAPTER XV.

INSECTS INJURIOUS TO STAPLE CROPS.

CHAPTER I.

INJURY DONE STAPLE CROPS BY INSECT PESTS.

Ever since the plague of locusts in the time of the Pharaohs, insects have maintained a continual opposition to agriculture. History is replete with accounts of insect scourges and the enormous losses occasioned by them. And instead of diminishing with the advancement in agricultural methods, injurious insects have undoubtedly become both more numerous and more destructive in modern times. Every now and then we hear of communities assembling for prayer and fasting to appease the Almighty, whose wrath has hurled a new insect plague against them. But a little reflection will show that these scourges are entirely due to natural causes. In fact such injuries are very largely due to man himself, who, in trying to subdue Nature by the clearing and cultivation of the land, has deprived the insects of their natural food. Thus they must needs feed upon that which is substituted by him, and as it is less abundant than the former wild vegetation, the number of insects and the injuries they inflict are more

apparent. But the native insects are by no means entirely responsible for this condition. Foreign insects are constantly being imported in one way or another, sometimes already being established pests in other lands and sometimes only becoming so under their new surroundings. These are even more injurious than those native, for whereas many of our native birds, insects, and diseases constantly prey upon native insects and thus keep their numbers in check, the enemies of imported pests rarely accompany them, and they thus increase at an alarming rate and do enormous damage before they are attacked by the natural enemies of similar native pests.

American farmers have learned from sad experience of the severe losses occasioned by insects, but few realize their enormity when considered as a whole. Several calculations of these losses have been made by competent authorities, who practically agree that one-tenth of the total agricultural product of the United States, or $300,000,000, is but a conservative estimate of the loss annually sustained by this country. But when this statement has occasionally been made by the author it has been met with a look of incredulity which very plainly indicated that he was thought to have a very elastic imagination. A careful collection of such data as may be confided in as accurate shows that the above estimate is entirely correct. Considerably over one-half of this loss is upon the staple crops, the remainder being upon truck crops, fruits, domestic animals, and timber.

Growing Cereals.—Probably no other insect does so wide-spread damage as the Hessian Fly, attacking our chief staple, wheat, as well as rye and barley. One-tenth of the whole crop, valued at $40,000,000, is generally con-

ceded to be destroyed by this pest every year, and in certain sections the loss often amounts to from 30 to 50 per cent. If the loss to rye and barley be put at one-fourth the loss of wheat, it amounts to about $1,000,000. From various estimates made at different times during that period, Prof. F. M. Webster states that $330,000,000 represents the loss from the depredations of the Chinch-bug since 1850, or $7,000,000 per annum, which has been largely confined to the States of the Mississippi Valley. Corn has a host of insect enemies. Frequently the Corn Root-worm has damaged the crop to the extent of 10 to 20 per cent in many of the largest corn-growing States. The annual loss on this crop due to insects is certainly not under 5 per cent, or $37,000,000. Thus with only the above figures we see an annual loss of $85,000,000 upon growing cereals.

Stored Grain.—But stored grain has its insect pests also, which are especially injurious in the South. Mr. F. H. Chittenden, of the U. S. Department of Agriculture, places the loss on stored corn in the seven Gulf States at $20,000,000, or 20 per cent of their crop. If only one-fourth of this amount, or 5 per cent, of the rest of the country's stored corn were thus lost, it would amount to $40,000,000. Twenty million dollars, or 3 per cent of the value of all other stored grain, certainly no more than cover the loss sustained upon it and other stored products subject to insect pests, which gives an approximate total of $60,000,000 damage to stored products.

Grass and Hay.—A host of grass and clover insects damage the hay crop. Half a million dollars have frequently been given as the loss sustained from the Army-worm alone in individual States. Five per cent of the

hay crop, or $20,000,000, fairly represents the loss upon this crop and pasture-lands due to insects.

Cotton.—The cotton-plant has a number of serious enemies, of which the Cotton-worm, Boll-worm, and Boll-weevil are the worst. In 1880 the United States Entomological Commission valued the annual ravages of the Cotton-worm at $30,000,000, but, thanks to their careful study of the pest, the damage done by it has been greatly lessened in recent years. But the Boll-weevil has now presented itself in Texas. In 1894 it damaged the Texas crop to the extent of $8,000,000, and its injuries are not reported as having diminished. Thus $15,000,000 must be a low estimate for the insect depredations upon cotton.

Tobacco.—The tobacco crop, valued at $25,000,000, has a horde of insect enemies at all stages of its existence, which will easily consume 8 per cent of it, or $2,000,000.

Potatoes.—The Colorado Potato-beetle does not do that crop so serious an injury as formerly, but some new enemies to it have appeared, and a loss of $10,000,000, or about 6 per cent of the value of that crop, is undoubtedly caused by our six-legged foes.

Surely, when we include the injury done to fruits, truck crops, domestic animals, and timber, $300,000,000 is a conservative estimate of the price these apparently insignificant little insects are annually costing this country.

Yet there is another aspect to the matter. "One man's loss is another man's gain" is never more true than as regards these losses occasioned by insects. For, through wide-spread injury by them, prices rise; while if these injuries were not done and correspondingly large crops were placed upon the market, prices must surely fall.

These estimates of losses due to insects are then very largely comparative. Yet, to a large extent, they are still real losses, the same as are those occasioned by fire and storm. For though a small crop may bring better prices, it is usually at the expense of individuals or communities which have sustained exceptionally heavy losses. Were these losses evenly distributed among all those producing a given crop, there would be no real hardship to them; but such is by no means the case.

All this, then, goes to emphasize the fact that the successful farmer—as the successful man in any other trade or profession—is the one who is able to overcome obstacles which, though possibly ruining his neighbor, are making a good market for his special crop. And these insect pests can be largely overcome. The millennium will doubtless come before the farmer will be able to stop fighting them, but a large part of the damage by them can be prevented at a cost which renders it profitable. Rational methods of general farm practice with the proper use of apparatus and insecticides, even such as are now known, and in which improvements are being constantly made, if intelligently used by American farmers, would save to them fully two-thirds of this enormous loss.

CHAPTER II.

STRUCTURE AND DEVELOPMENT OF INSECTS.

THE more experience the farmer has with insect pests, the more he comes to realize that if he would successfully combat them, he must have a certain amount of necessary knowledge concerning their structure and growth.

In general, the *artificial* means which may be effectually used to combat an insect pest will very largely depend upon the anatomical structure of the insect, while control by general methods of *culture* will depend upon a knowledge of the peculiarities of its life-history.

The value of a proper understanding of these important factors in insect control is therefore apparent.

General Structure of an Insect.

The body of an insect is composed of three separate parts, the head, thorax, and abdomen (Fig. 1), each of which is composed of several rings or segments. To the head are attached the jointed antennæ, or feelers, the compound eyes, and the mouth-parts, which are described below. Each of the three segments of the thorax bears a pair of legs, and adult insects usually possess one or two pairs of wings upon the last two segments of the thorax. The abdomen is composed of nine or ten segments, but

bears no appendages save the ovipositor of the females of certain orders.

Harvest-mites, or "daddy-long-legs," sow-bugs, thousand-legged worms, and similar vermin are often popularly called insects, but all of them can readily be distinguished from true insects by their possessing more than six legs,

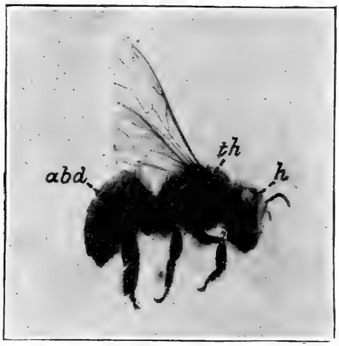

FIG. 1.—Honey-bee, showing three principal regions of the body of an insect :—*h*, head; *th.*, thorax; *abd.*, abdomen. (Original.)

the harvest-mites and spiders having eight and the others many more.

How Insects Grow.

With rare exceptions insects hatch from eggs laid by the adult females. Upon hatching they are but little larger than the eggs, and often bear but little resemblance to their parents. Thus the young caterpillar would never be recognized as the immature stage of the butterfly by one unfamiliar with its transformations. Grasshoppers and some other insects, however, upon hatching from the egg bear a marked resemblance to the adult form, except that they lack wings.

Complete Metamorphosis.—But let us return to the caterpillar and follow it through its short but interesting life. Upon hatching from the egg it at once commences to feed and grows very rapidly. But before long an obstacle to further growth arises. Unlike higher animals, insects possess no internal skeleton or framework for the organs of the body, but the outer skin becomes hardened and to it the muscles and ligaments are attached. This hardening of the skin is best seen in the horny wing-covers of the beetles and is due to the secretion of a hard substance called chitin. This chitin is secreted by all parts of the skin in greater or less degree, and thus forms a sort of shell for the whole body. Though this hardening is not so apparent in larvæ as in adult insects, it is always present, and it is for this reason that when the young caterpillar has made a certain growth it is forced to shed its skin, which refuses to expand further, in order to develop more fully. Thus the skins of insects are shed several times (see Fig. 2, *b*),—usually five or six, but sometimes as many as twenty,—this process being known as "molting." During its life as a caterpillar, which is called the "larval stage," and during which it is called a "larva," it is an elongate, worm-like creature, with six short, jointed legs on the three thoracic segments, a pair of fleshy false legs or pro-legs on the last abdominal segment, and probably several pairs of pro-legs between these and the true legs. No traces of wings can be seen, but the body is often covered with hairs, spines, or warty tubercles.

But with the next molt the insect changes in appearance most radically, becoming a pupa, or chrysalis as this stage is termed for butterflies. During the pupal stage the insect remains dormant either in a small cell slightly under

the surface of the earth, or in a silken cocoon spun by the caterpillar, or merely attached to the food-plant by a

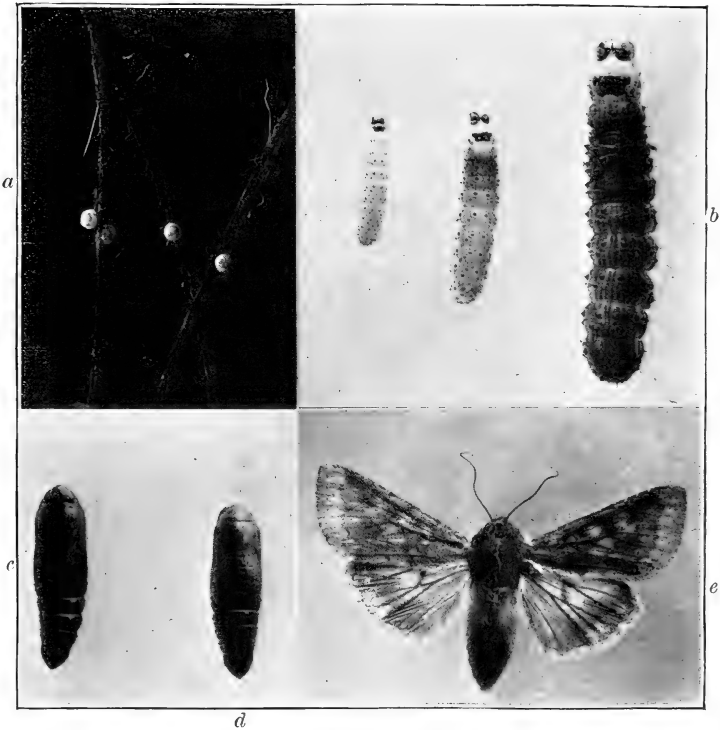

FIG. 2.—Complete Metamorphosis. The different stages of the Corn Ear-worm (*Heliothis armiger* Hübn.). *a*, eggs on corn-silk; *b*, the first three larval stages; *c*, pupa from below; *d*, same from above; *e*, adult moth—all enlarged; *b*, about twice natural size. (Original.)

strand of silk or the cast larval skin. In many of the Diptera,—the order including flies, mosquitoés, gnats, etc.,—however, the last larval skin is not shed, but hardens and forms a case—called a puparium—within which the pupal stage is passed.

The typical pupa (Fig. 2, *c*, *d*) of a butterfly or moth is of a more or less oval shape, rather resembling the adult insect than the larva, with the wings and antennæ tightly folded at the sides, the legs drawn up snugly together under them, and the head and mouth-parts bent upon the breast, or sternum. But all of these parts are not always recognizable, the legs and mouth-parts being sometimes lacking. Gradually the adult insect develops, and at last the pupal skin is broken open and the airy butterfly emerges to enjoy a short life and perpetuate the species. Such a series of transformations is that commonly found among butterflies and moths (Lepidoptera), beetles (Coleoptera), flies (Diptera), and bees (Hymenoptera), and is known as a *complete metamorphosis*. All of these insects normally pass through four stages, the egg, larva, pupa, and adult.

Incomplete Metamorphosis.—In contrast to this mode of development is that of the grasshoppers (Orthoptera), bugs (Hemiptera), and some other insects. As already stated these are much like the adult upon emerging from the egg. With each molt they become larger and small wing-like pads gradually appear on the sides of the thorax. There is no dormant or pupal stage, the adult insect differing from the previous stages in having fully developed wings, being larger, and often by an accompanying change of markings. The immature stages of such insects are called *nymphs*, and this development an *incomplete metamorphosis*, having but three stages, the egg, nymph, and adult (Fig. 3).

The time occupied by the complete life-cycle of an insect varies from a week or ten days for the plant-lice to thirteen or seventeen years for some Cicadas, and is entirely dependent upon the habit of the species and the climate.

A correct knowledge of the exact time and conditions under which the transformations occur for each individual

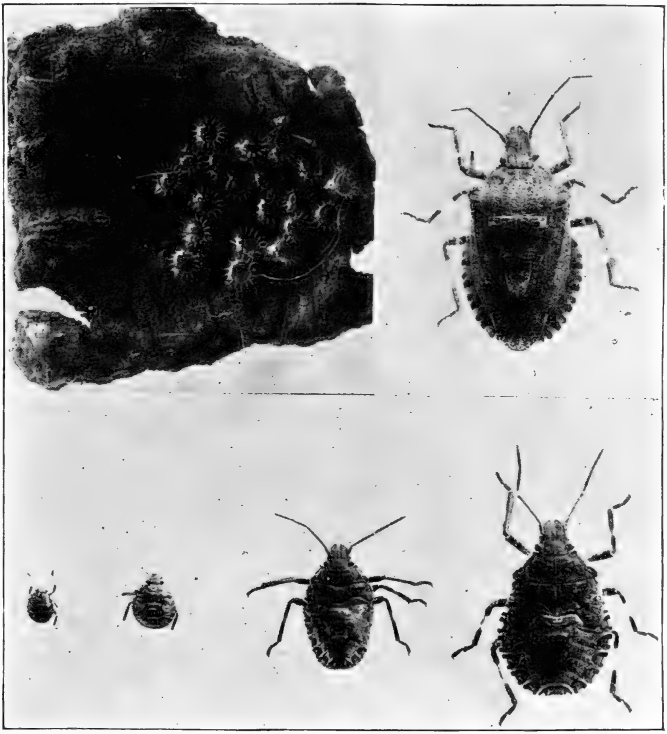

FIG. 3.—Incomplete Metamorphosis of a Bug (*Brachymena 4-pustulata*). *a*, eggs; *b*, adult bug; *c*, different stages of young bugs or nymphs. (Original.)

insect pest is therefore often most essential when seeking means for its control.

How Insects Feed.

The material to be used in combating a given insect is almost entirely dependent upon the structure of its mouth-

parts. Much Paris green is wasted upon insects unable to eat it and which it will, therefore, never kill.

Insects may be roughly divided into two classes, those which bite and those which suck their food. Among the former are the beetles, grasshoppers, the larvæ of butterflies and moths, and the larvæ of saw-flies; and among the

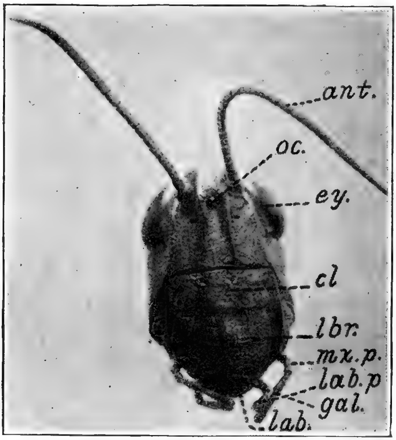

Fig. 4.—Front-view Face of Grasshopper (*Schiztocerca americana*). *ant.*, antenna; *oc.*, ocellus; *ey.*, eye; *cl.*, clypeus; *lbr.*, labrum, or upper lip; *mx.p.*, maxillary palpus; *lab. p.*, labial palpus; *gal.*, galea, lobe of maxilla; *lab.*, labium, or under lip. (Original.)

latter are butterflies, flies, bees, and bugs, while the larvæ of most flies and bees do not possess mouth-parts homologous with those of the above.

Biting Mouth-parts.—Mouth-parts typical of those of biting insects are easily seen in the grasshopper (Figs. 4, 5, and 6). In brief, they consist of an upper and a lower lip, between which are two pairs of jaws which work transversely. The upper pair of jaws, or *mandibles* (*md.*), are stout, short, and horny, usually sharpened at the tip,

slightly serrated at the margins, and flattened at the base. The lower pair of jaws, or *maxillæ* (*mx.*), are longer, not so strong, and to each of them is attached an accessory lobe, and a jointed style called a palpus or feeler. At each

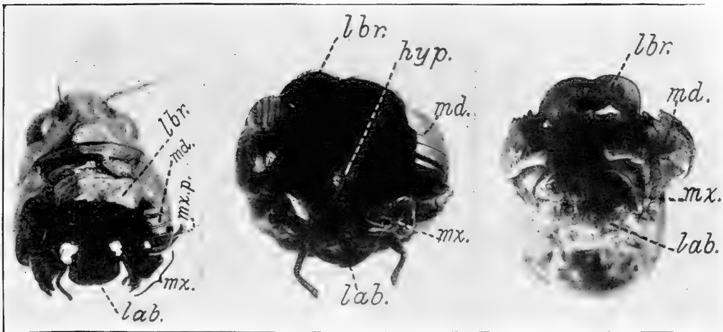

FIG. 5.—Mouth-parts of Grasshopper, separated to show position and relation, *a*, from above the mouth; *b*, looking into the mouth; *c*, from below the mouth. *lbr.*, labrum, or upper lip; *md.*, mandible or biting-jaw; *mx.*, maxilla, or second jaw; *lab*, labium, or under lip: *hyp.*, hypopharynx, or tongue; *mx.p.*, maxillary palpus. (Original.)

side of the lower lip is another palpus, these palpi being sensory organs.

Sucking Mouth-parts.—In the sucking insects these mouth-parts are prolonged into a tube through which the juices of the food plant—or animal—are sucked. In the plant-lice and other bugs the lower lip is elongated so that it forms a tube, and the maxillæ and mandibles consist of long hair-like bristles, or setæ, enclosed within this tube (Fig. 7). The tip of this beak is rested upon the surface of a leaf into which the setæ are thrust, lacerating the tissue, and by a pumping process of the mouth the juices are sucked up through the beak. The structure of the mouth-parts of the various orders of sucking insects varies

considerably, but all agree in that their food must be sucked up in a liquid state. Any application of a poison-

FIG. 6.—Cicada, showing Mouth-parts of a Bug, a Sucking Insect. *a*, seen from below, beak or rostrum (*ro. G.*) reposing between forelegs; *b*, head removed; *e*, eye; *lbr.*, labrum; *md.*, mandible-setæ; *mx.*, maxillary setæ; *lab.*, labium. (Original.)

ous spray to the surface of foliage will be of no avail against them, though sure death to most biting insects

which chew the leaves, and sucking insects must therefore be killed by other means.

How Insects Breathe.

In the side of one thoracic segment and each abdominal segment except the last, of a caterpillar or larva, is a small

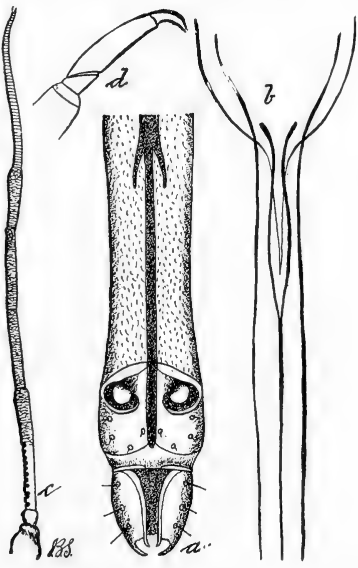

FIG. 7.—Mouth-parts of a Plant-louse; *a*, the jointed beak; *b*, the lancets, much enlarged; *c*, antenna; *d*, foot. (After J. B. Smith.)

oval spot, in the centre of which is a slit closed by two membranous lips. These apertures are called spiracles or stigmata (Fig. 8, st_1–st_{10}), and are the openings of the respiratory system. Similar openings are to be found in all insects, though not so easily seen in the adults. Connecting these spiracles is a pair of tubes on each side of the body, throughout its length, from which branch off

smaller tubes to all of its organs and tissues. Fresh air is thus inhaled to all parts of the body through these tubes (Fig. 8, *tr*).

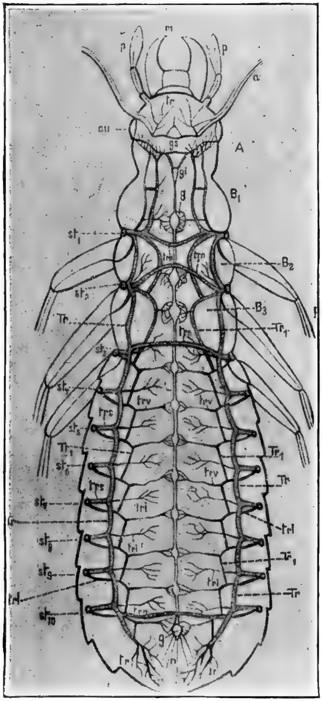

FIG 8.—Diagram of tracheal or breathing system of an Insect. st_1–st_{10}, the ten pairs of spiracles; *A*, head; B_{1-3}, the three segments of the thorax; *Tr.*, the two main tracheal trunks; *trs.*, trachea leading from the main trunk to the spiracle; *tru.*, trachea connecting the two main trachea; *tri.*, visceral trachea; *tro.*, ventral trachea; *tr.*, the anterior termination of the trachea; *g.*–*g.*, nerve-cord with ganglia to which go branches of the visceral trachea; *au.*, eyes; *a*, antennae; *p*, palpi; *m*, mandibles; p_1–p_3, bases of the legs. (After Kolbe.)

The blood of insects does not circulate through any system of tubes as it does in the higher animals. Along

the middle of the back, above the alimentary canal, is a long tube popularly called the heart (Fig. 9, *h*; Fig. 10, *dv*). This heart is composed of a number of chambers each of which is funished with side valves for admitting blood from the body-cavity. The blood coming into the heart from the body-cavity is propelled forward toward the head, where it again flows into the body-cavity. Thus various currents of blood are maintained throughout the

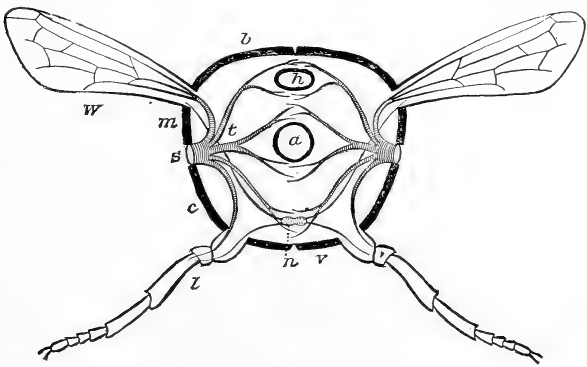

FIG. 9.—Ideal section through an insect. *a*, alimentary canal; *h*, heart; *n*, nerve-cord; *s*, stigmata; *t*, tracheal tubes; *l*, legs; *w*, wings. (From Riverside Nat. History.)

body, but other than the heart there is no system of blood-vessels, the blood merely filling the body-cavity around and through the various organs and tissues. Constantly flowing around the respiratory tubes or tracheæ, the blood is quickly and thoroughly purified, though the exact manner in which this is done is not definitely known. The respiratory system has absolutely no connection with the mouth or pharynx (Fig. 10, *ph*), as have the lungs of the higher animals, and if an insect is to be suffocated, it must be done by closing the spiracles. It is in this way

that tobacco-dust, lime, pyrethrum, and similar insecticides kill sucking insects by penetrating the spiracles and choking the tracheal system. Whale-oil soap, kerosene emulsion, and the other "contact" insecticides, or "irritants," may also stop up the spiracles and thus cause death, but they act chiefly as "irritants," penetrating the

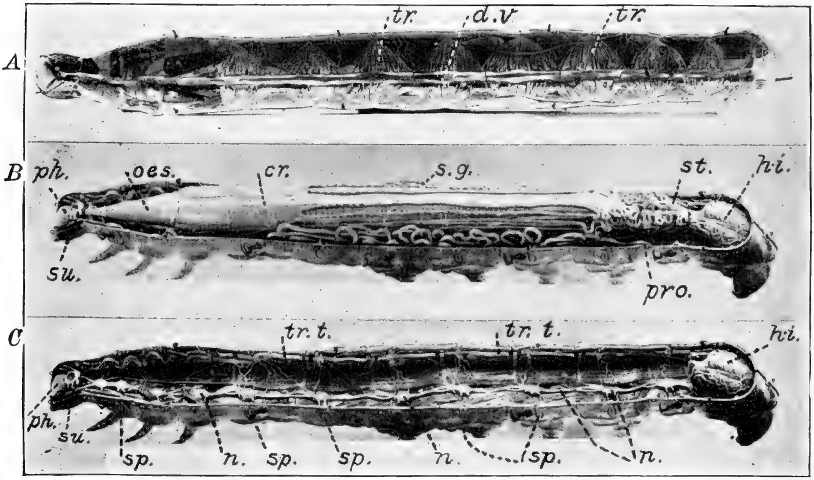

FIG. 10.—Internal Anatomy of Silkworm. *A*, the upper, or dorsal, body-wall seen from within; *B*, the back of the silkworm removed, showing alimentary canal; *C*, alimentary canal removed, showing nervous system and tracheal trunks; *tr.*, trachea; *d.v.*, dorsal vessel or heart; *ph.*, pharynx or mouth; *su.*, supraœsophageal ganglion; *sp. sp.*, spiracles or breathing-pores; *n*, nerve-cord; *tr.t.*, tracheal trunk; *oes.*, œsophagus or throat; *cr.*, crop; *s.g.*, silk-gland; *pro.*, proventriculus or grinding-stomach; *st.*, stomach; *h.i.*, hind-intestine. (Photo. by author from Azoux model.)

skin and thus killing the insect. When insects are killed by means of a gas such as carbon bisulfide or hydrocyanic acid gas, they are truly asphyxiated by a substitution of these gases for air, the same as are higher animals by the use of anæsthetics.

Though arsenical poisons are generally used as sprays for biting insects, soft-bodied caterpillars and similar larvæ are often killed by the use of contact insecticides, which affect them the same as sucking insects.

The reader will observe that, almost without exception, the remedies advised for different insect pests in the following pages are determined by some peculiarity, either of structure or development, of the insect to be combated.

CHAPTER III.

GENERAL FARM METHODS AGAINST INSECT PESTS.

In the following pages artificial means of combating insect pests, such as spraying with insecticides, are not as often the remedies or preventives given as those which consist of some method of general farm practice. That such should be the case is but natural, for the staple crops, being cultivated in large areas, can hardly be treated with sprays or mechanical devices, in many instances, with any degree of profit. The best methods to employ against most of the insects affecting the staple crops are what might be termed cultural methods, consisting of some mode of culture or handling the crop which fatally interferes with the development of a given insect pest. Such treatment is far less simple in many instances, however, than the use of a spray-pump or powder-gun. In the latter case the farmer merely waits until he observes a crop being injured and then with a liberal application of poison destroys his insect enemies; but in using the former method he must have a more or less accurate knowledge of the life-history of the insect which he wishes to combat. It will also be necessary for him to observe or ascertain the usual dates of the transformations of various insects for his particular locality, as they vary considerably for different latitudes and altitudes, and to make due allow-

ance for any variation of these dates on account of the peculiarities of the individual season.

Looking Ahead.—Few farmers, in planning the management of their land and crops for the coming season, consider the effect which any given procedure will have upon the injurious insects with which they may have to contend. A field which has for several years been in wheat, corn, or tobacco may be sown with some other crop for the sake of soil improvement, or may even be favored with a green-manuring of rye, crimson clover, or cow-peas; but how often is it considered necessary to rotate crops in order to lessen insect pests? In most cases the answer would doubtless be, "Not until some noticeable loss has been suffered from their injuries." That this is a mistake may be seen from a brief survey of the best methods for combating our worst insect pests.

For this purpose let us take the list of sixty-three insects given in the Year Book of the United States Department of Agriculture for 1898 as a basis, it being carefully compiled by experienced entomologists.

But in passing, though foreign to our theme, it may be interesting to note that of these sixty-three insects twenty-seven have been imported from foreign climes, thirty-one are native, and four are of doubtful origin, so that we can correctly say that fully one-half of our worst insect pests are imported. Among those native to the United States are the Chinch-bug, Corn Root-worm, Cutworms, Locusts, and Colorado Potato-beetle; while among those imported are the Angumois Grain-moth, Gypsy Moth, Codling-moth, Cotton-worm, Sugar-cane Borer, Grain Weevils, Hessian Fly, and San José Scale.

Of these sixty-three pests eight infest stored grains and

household goods, and may be exterminated by the fumes of carbon bisulfide; and five are insects affecting cattle, and are combated with various washes.

Thus only fifty are really to be considered insects of the farm crops. Of these, three are controlled by "ditching," three by mechanical means or devices, and for two of them hydrocyanic acid gas is sure death, while a spray of whale-oil soap is advisable for two others, a spray of kerosene emulsion for six, and of Paris green or London purple for fifteen, these sprays, etc., being used largely for orchard pests, which comprise eighteen of the fifty. But for the control of many of the insect pests affecting the staple crops, and which are, therefore, of the greatest economic importance, we have so far been unable to devise anything better than a judicious manipulation of purely natural agents, and for the control of twenty-three of the fifty farm insects listed, or nearly one-half, and 75 per cent of those outside the orchard, such methods must be mainly relied upon.

Clean Farming.

After a crop has been harvested, there is usually some portion of it which is allowed to remain on the land. In this refuse the insects peculiar to the crop often go on multiplying until winter, and greater damage to the crop in the following year is therefore probable. Thus the Wheat Joint-worm and the Corn Stalk-borer both winter in the stubble of those crops, the Potato Stalk-borer remains for some time in the vines, and numerous other cases might be cited. It is therefore of importance in our warfare against insect pests that the remains of a crop, stubble, vines, leaves, or stumps, as it may be, should be

removed from the field as soon after it is harvested as possible. Such material allowed to remain in the field also furnishes the adult insects an excellent place in which to hibernate over winter. Much can be done to rid a field of insects by cleaning it so thoroughly as to deprive them of shelter during the winter, during which time they hibernate under all sorts of rubbish, grass, and weeds, in fence-rails, loose bark of trees, etc. This fact may also often be utilized by first carefully cleaning a field and then leaving one or two piles of rubbish in which various insects will assemble during the winter, when they can be easily caught by burning the whole. Such a trap will be more effectual in catching the insects affecting truck crops than those of the staple crops.

Weeds.

But even when all the piles of litter and rubbish have been carefully cleared up many of our native insects will merely leave them for some common weed upon which they will feed and breed during the season, and, if it should be earlier than the cultivated crop, will continue upon it the following spring until the cultivated crop is to be secured for food. "Volunteer" plants should be included with weeds in this connection, as they frequently serve the same purpose. Thus the Cotton Boll-weevil feeds upon volunteer cotton during the spring, and the Hessian Fly on the volunteer wheat during late summer, while the Corn Root-louse lives on the roots of the smart-weed until corn is out of the ground. Then, too, many injurious insects feed in the larval or adult stage upon some common weed, while in the other stage they are injurious to a cultivated crop. The flea-beetles thus feed upon the

roots of Solonaceous weeds during the larval stage, and attack all sorts of garden and truck crops as adults; one of the Corn Bill-bugs lives in the roots of a wild grass as a larva, but is injurious to corn as a beetle. The weeder can, therefore, be occasionally used as an insecticide as effectually as the spray-pump.

Burning.

To start a prairie fire in order to destroy all the insect life of the plain might prove to be poor policy, but the careful use of the torch has a distinct place upon the farm in controlling its insect foes. The burning over of stubble and grass land will very largely aid in or secure the entire extermination of Army-worms, Chinch-bugs, Locusts, and Wheat Joint-worms. Raking up and burning the vines will be excellent practice against the Squash-borer, Squash-bug, Potato Stalk-borer, and Hop Plant-louse, while the removal and burning of all wild plum-trees in their vicinity will greatly lessen the damage to hops by the latter pest.

Deep Fall Plowing.

Deep fall plowing is being increasingly recommended for the reduction of many pests, and will be found to be of advantage for the Corn Stalk-borer, Corn Ear-worm, Cutworms, Locusts, and Wireworms. In both burning and fall plowing the object is to kill that stage in which the insect passes the winter.

But this method does not affect all of these insects in the same manner. Some insects will be destroyed by having the cells in which they have gone to pass the winter broken up, and being thrown up to the surface, they will

be killed by the weather before they again provide themselves with winter quarters. Among these are those which hibernate over winter as larvæ, and those which pass it in the pupal stage. Among the former may be mentioned the Cutworms and the Corn Stalk- or Sugar-cane-borer larvæ. Of those passing the winter as pupæ, the Corn Ear-worm is a good example. It goes into the pupal stage in the fall, and this method of breaking up the pupal cells is practically the only way of combating it upon corn land.

But whereas some insects are destroyed by exposing them on the surface, others may be literally buried alive and thus killed. One of the best instances of the value of fall plowing in this way is in the destruction of grasshoppers' eggs. If they be turned under to the depth of five or six inches after they are laid in the fall, the young hatching from them in the spring will be utterly unable to regain the surface and will thus be smothered to death. Other insects which pass the winter in the pupal stage, but whose pupæ are encased in a tough cell not easily broken open, may also be killed by being turned under in this manner. In fact, even adult insects may be so handled. After the plants are all thrown out of the ground in November the adults of the Mexican Cotton Boll-weevil can be readily caught in this way and plowed under so deeply that they can never regain the surface. Young grasshoppers are also destroyed in a similar manner just after they have emerged from the eggs in the spring.

It is a homely, common-sense method, but with a correct understanding of their life-histories it may be used to good advantage against many of our most common and injurious insects.

Drainage.

The Rice-weevil can be largely controlled by proper drainage, and the Corn Bill-bugs are usually injurious only on land adjacent to or recently reclaimed from swamp land, and disappear with the introduction of proper drainage.

Fertilizers.

In general, land covered with barnyard manure presents more favorable conditions for the development of insects than that fertilized with mineral fertilizers, sometimes furnishing them food and always affording a good shelter for the cold of winter. On the other hand, it is claimed that kainit, lime, and nitrate of soda are often of considerable value in controlling, driving out, or preventing the attacks of insects. A liberal application of fertilizers in any form will always be of great value in preventing loss from root-feeding insects by enabling the plant to outgrow the injury and mature fruit in spite of it.

Poultry.

A flock of chickens or turkeys following the plow will pick up a great many White Grubs and Cutworms and can readily be trained to this—for them—rather pleasant task. In many tobacco-growing sections large flocks of turkeys are raised especially for destroying the Tobacco Hornworm and are slowly driven through the tobacco-fields several times a day.

Trap Crops.

Doubtless the reason that trap crops are not more in favor with the farmer is because their successful use

requires more or less of a knowledge of the life-history and habits of the pest to be caught; yet this is easily acquired by a little observation and reading, and the men who combat these pests successfully are those who have such a knowledge of them. Let us consider, then, one or two of the more important cases where this principle may be used to advantage.

The Harlequin Cabbage-bug is a southern insect, but it has recently been found in southern Pennsylvania and seems to be gradually working northward. When this insect has succeeded in reaching the cabbage-field it is an exceedingly difficult matter to prevent serious injury by it. If, however, a crop of early kale is planted the previous fall, the bugs which hibernate over winter will attack it in the spring, and may then be killed by spraying them with pure kerosene, and the danger to the cabbage crop be thus largely averted.

The Corn Ear-worm, Tomato-worm, Tobacco Bud-worm, or Cotton Boll-worm, as it is variously known in different sections of the country, according to the crop which it most commonly infests, is one which must be treated almost entirely by means of a trap crop of corn. Unfortunately for that plant, however, this method cannot, of course, be of use in protecting the corn-field, where it must be controlled as best it may by breaking up the cells of the hibernating pupæ by late fall plowing. But as corn is the favorite food of the worms, and the moths will invariably deposit their eggs in its silk, tobacco, cotton, and possibly tomatoes may be largely protected by a proper handling of the corn crop. By planting an early crop of corn, the moths will deposit their eggs in the silk; and before the worms have become full grown it

should be cut and fed to stock. Another crop should have been planted near by, or in alternate rows with the previous one, so as to mature a little later, and it should be handled in the same manner. Even a third will prove to be of considerable value. In this way the worms will be trapped in the corn, and the more valuable crop protected. Sweet corn is the best to use, and a few strips will often be found to be of great value when properly used.

Numerous other instances of the successful application of this principle might be cited, and several are mentioned under the discussion of individual insects. With a correct knowledge of the habits of a given pest, the ingenious farmer will often find the method one of great value.

Time of Planting.

The proper time of planting is of importance in the protection of many crops from insect attacks. Late-sown wheat is usually exempt from the attack of the Hessian Fly. Late-planted corn is much less affected by the Stalk-borer than that planted earlier in the season.

Rotation.

A very important, if not indeed the most important, factor in insect control is the rotation of crops in such a manner that no single crop shall be continuously grown on the same land, or any two crops nearly related botanically. Allowing land to remain in meadow for some time forms a breeding-ground for White Grubs, Cutworms, and Wireworms, and if it is then desirable to cultivate the land, it should be planted in potatoes or some such crop unrelated to the grasses. It may then be planted with small grains, and then with corn; for if the number of

these insects in the grass land be at once concentrated upon the comparatively few corn plants, the injury will be much more severe than if the change be a gradual one, with first a crop not of the grass family which would be largely immune from their attacks, and then a small grain. The value of rotation is possibly best illustrated in the case of the Western Corn Root-worm, which is never injurious to corn after the land has been in a small grain or clover. The Hessian Fly, Wheat Isosoma, Wheat Plant-louse, Wireworms, and many other of our worst pests may be largely controlled by a rapid rotation, and their increase and consequent depredations are very often due almost entirely to a lack of such practice, which is also of the utmost importance in preventing soil depletion.

Thus a proper understanding of the pests with which he has to deal and a timely consideration and application of these homely methods may be of the greatest value, and indeed often the only available means for the control of the larger part of the insect enemies of the general farmer.

CHAPTER IV.

BENEFICIAL INSECTS, PREDACEOUS AND PARASITIC.

Ladybird-beetles.

After his strawberries have been ruined by the Strawberry-weevil, the garden truck by Cutworms, the wheat despoiled by the Hessian Fly, the melon-patch fallen a prey to plant-lice, and the fruit crop has been a failure on account of the Codling-moth, Plum Curculio, and San José Scale, it is scarcely surprising that the farmer does as one of my acquaintances did and "orders the hands to kill everything that crawls."

But such would be entirely too heroic a measure, and if strictly adhered to the remedy would be as bad as the disease, for it would mean not only useless labor, but the destruction of the most effective means whereby insect pests are held in check. We pride ourselves—and justly—that with our Paris green and kerosene sprays and gas tent most of the crops can be effectually protected; but were it not for those other insects which feed upon these injurious forms, what an enormous and, in some instances, almost futile task it would be!

Among these beneficial insects the little Ladybird-beetles of the family *Coccinellidæ* are entitled to be in the first rank. Almost all the beetles and larvæ feed upon

plant-lice and scale insects. Of such value are those feeding upon scale insects that not many years ago a large number of Australian species were imported into California that they might prey upon the San José and other scales. One of these was eminently successful and almost completely destroyed the Cottony Cushion-scale.

Of those feeding upon plant-lice, one of the most common is the Nine-spotted Ladybird (*Coccinella novemnotâta*). This beetle is about one-fourth of an inch long, with black head and body. The wing-covers are orange-yellow marked with nine black spots—four on each side and one on the central suture. The larva has been fancied to resemble a miniature alligator; it is nearly twice as long as wide, almost black, marked with bluish and orange spots, and has long legs, which carry it around quite rapidly. The beetles hibernate during the winter and come forth in the spring and lay their eggs wherever the young will be able to find food when they hatch. When the larva has satisfied its ravenous appetite and become full grown it fastens itself to the food-plant—seemingly by its tail, if such a term might be allowed,—transforms to the pupa, and in a week or ten days the adult beetle emerges from the pupal skin. This life-cycle is repeated several times during the summer season, before the fall brood turns into winter quarters.

Another very common form among plant-lice on garden truck is the little *Adalia bipunctata*, or Two-spotted Ladybird. It is slightly smaller than the preceding, and with only one black spot on each wing-cover (Fig. 11).

Several other species in the genus *Hippodamia* are very useful, and among them the Convergent Ladybird (*Hippodamia convergens*) is one of the best known. Its

name is received from two white dashes on the black thorax, which converge posteriorly. The thorax has also

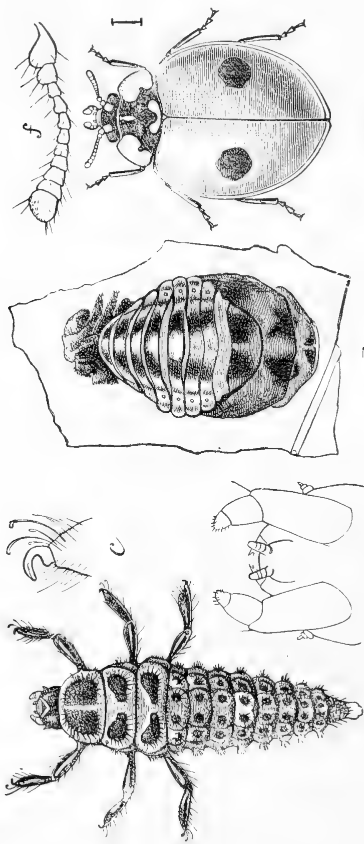

FIG. 11.—*Adalia bipunctata.* *a*, larva; *b*, mouth-parts of same; *c*, claw of same; *d*, pupa; *e*, adult; *f*, antenna of same—all enlarged. (After Marlatt, U. S. Dept. Agr.)

a white margin, and there are thirteen black dots on its orange wing-covers. These larvæ and beetles are very common among the plant-lice on melon-vines, and are an important factor in their extermination. They have also

been noted for eating the Black Peach Aphis and many other plant-lice.

A form which is often very abundant among lice on corn

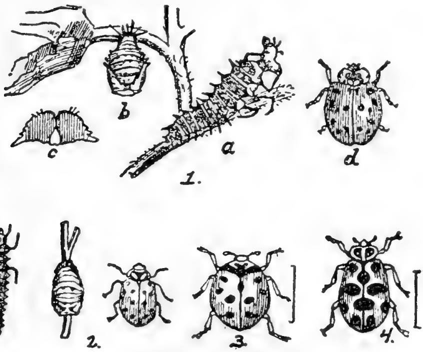

FIG 12.—1, the Fifteen-spotted Ladybird: *a*, larva eating plant-louse; *b*, pupa; *d*, beetle. 2, the Convergent Ladybird (*Hippodamia convergens*), larva, pupa, and beetle. 3, the Nine-spotted Ladybird (*Coccinella 9-notata*). 4, *Megilla maculata*. (After Riley.)

is *Megilla maculata*. The head, thorax, and wing-covers are a dark pink, with two black spots on the thorax and ten on the wing-covers. Such numbers of these little fellows have frequently been found huddled together under the rubbish at the base of some tree in a last year's cornfield that they might be taken up by the handful without difficulty. Many other species feed upon plant-lice, but the above are the most common, and all bear a resemblance to one another, being generally orange or red with black spots, and of a characteristic round or

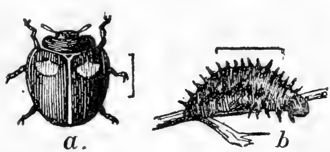

FIG. 13. — The Twice-stabbed Ladybird (*Chilocorus bivulnerus*). *a*, beetle; *b*, larva. (After Riley.)

oval form, flattened below, so that the legs may be drawn in under the wing-covers.

Those Ladybirds which feed upon scales are much smaller and black, though sometimes spotted with red or orange.

As far as known, there is no way in which these useful allies may be encouraged or increased in numbers, but it is trusted that the above may give such a brief view of their habits that fewer may be killed through ignorance concerning their true worth.

Syrphus-flies.

Besides the little beetles described above there is a family of flies, the *Syrphidæ*, many of whose larvæ feed upon plant-lice. This family is a very large one, and thus the habits of its different members vary considerably. One of them so closely resembles a honey-bee as to be almost indistinguishable from it. The larva of this fly (*Eristalis tenax*) is one of the common Rat-tailed Maggots which is found in putrid matter. It is thought that the old "bugonia" superstition of the ancients that bees came from maggots in dead animals, etc., was due to the confusion of this fly with the honey-bee.

In another group of the family, the adult flies of which also quite closely resemble bees, the larvæ are parasitic in the nests of honey- and bumble-bees, feeding upon their larvæ.

But the larvæ of possibly the most typical portion of the family, embracing the genus *Syrphus* and its near allies, are entirely predaceous upon plant-lice. Rarely can a colony of plant-lice be found without some of these little enemies hard after them.

The adult syrphus-fly is a very striking insect, with its dark green metallic thorax, and abdomen variously banded with yellow and black. The female fly lays her eggs upon some plant bearing plant lice. The l a r v æ which hatch from these are elongate, flattened maggots, about one-half an inch long, with hardly a trace of a head, but with four small hooks, which serve as jaws, projecting from the more pointed end of the body. These maggots are often of a light green color, and so like the color of the plants as to render them most difficult to be recognized. The young larvæ at once commence crawling over the plant in search of the aphids, and as soon as they come in contact with one it is firmly clasped by the small hooklets until the juices are sucked from its body. In this manner very

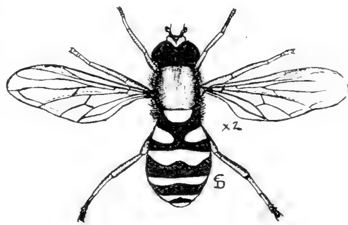

FIG. 14. — *Syrphus ribesii.* (Author's illustration.)

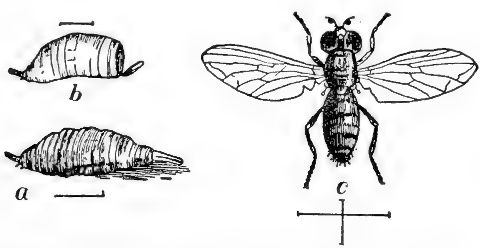

FIG. 15.—The Root-louse Syrphus-fly (*Pipiza radicans*). *a*, maggot; *b*, puparium; *c*, fly. (After Riley.)

large numbers are destroyed, a single maggot of the American Syrphus-fly (*Syrphus americanus*) having been observed to eat twenty-five Apple Plant-lice (*Aphis mali*)

in as many minutes. When the larva is ready to pupate it attaches itself to a leaf, and the larval skin dries up and forms a case or puparium inside of which the pupa remains until it transforms to the adult fly.

Though most of these larvæ feed upon plant-lice upon the leaves, one of them, the Root-louse Syrphus-fly (*Pipiza radicans*), lives entirely underground during that stage, and feeds upon the root-lice of the apple and the grape. None of this family are injurious, and as a large portion of them are so beneficial as to frequently destroy whole broods of plant-lice, they should not be disturbed in their good work if possible to avoid it.

The Ground-beetles.

If, as you scrape away the loose chips at the base of a tree in your door-yard, turn over an old log in the woodland, or pick up a fallen fence-rail, you will scrutinize the inhabitants under these shelters, a number of shining black beetles varying in length from one-fourth to one and one-half inches will usually be noticed. If the city reader be not so fortunate as to be familiar with or have access to these hiding-places, he may find large numbers of the beetles under any electric arc light during the warm summer evenings; for there they are having a sumptuous banquet upon the small flies and moths attracted by the glare. They are rarely seen at large during the day, as they are almost exclusively nocturnal insects, and from their habit of remaining almost entirely in or on the ground they are usually known as "Ground-beetles." As might therefore be inferred, they are exceedingly valuable to the farmer by destroying large numbers of noxious insects which pass a part or all of their existence

in the soil. Besides the glossy black forms which are most commonly seen, many are brilliantly marked with gold, green, purple, and iridescent tints.

The Fiery Ground-beetle (*Calosoma calidum*), so called on account of the wing-covers being dotted with bright gold, has many times been of great assistance in helping to rid a corn-field of Cutworms. The larvæ of this insect

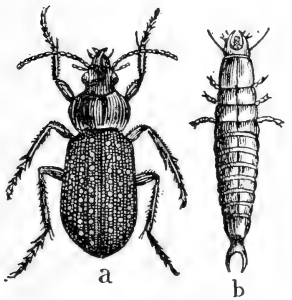

FIG. 16.—The Fiery Ground-beetle (*Calosoma calidum*). *a*, beetle; *b*, larva. (After Riley.)

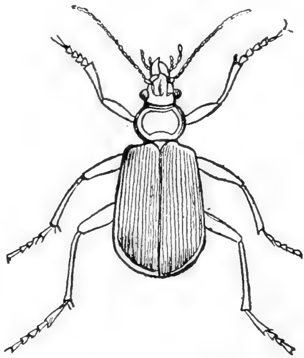

FIG. 17.—"The Searcher" (*Calosoma scrutator*). (After Riley.)

are about one inch in length, of a dark brown color, with the skin of a hard, horny texture like that of the beetle. They have strong, prominent jaws, and at the posterior end of the body is a forked appendage looking much like another pair of jaws. It is not only surprising that these larvæ will eat so large a number of cutworms, as they have frequently been known to do, but also that they will dare to attack such a formidable creature fully three or four times as large as themselves. But their assault is sharp and vigorous, and a single larva has often been seen

to kill and eat in a short time several full-grown cutworms. Many instances of the good work of this beetle are on record, among which one by the late Prof. J. A. Lintner might be cited, where he found them eating large numbers of the Corn-crambus—sometimes locally known as the Corn Bud-worm. Another somewhat larger beetle, called by Prof. J. H. Comstock "the Searcher" (*Calosoma scrutator*), and in fact one of the largest of the family, is a brilliant metallic green, bordered with a dark purplish blue, and has the good quality of having a very particular appetite, causing it to kill large numbers of caterpillars, but eating only part of each.

While in the earth as pupæ large numbers of the Colorado Potato-beetles are destroyed by members of this family, and one species, *Lebia grandis*, which is peculiar

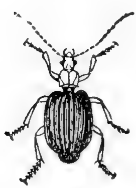

FIG. 18.—*Lebia grandis*. (After Riley.)

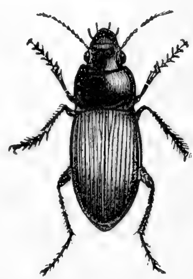

FIG. 19.—The Murky Ground beetle (*Harpalus caliginosus*.) (After Riley.)

in that the wing-covers are somewhat abbreviated, thus leaving the tip of the abdomen exposed, has been noticed on the plants eating the eggs and young larvæ of this old potato pest.

Another valuable species is one called by Dr. Riley the

Murky Ground-beetle (*Harpalus caliginosus*). Its larva is of considerable assistance to fruit-growers by eating large numbers of Curculio larvæ, which it secures from the plums after they have fallen to the earth. From a glance

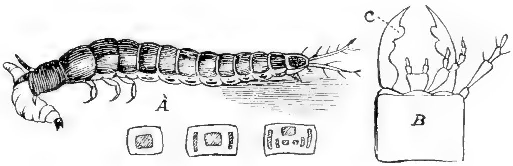

FIG. 20.—*A*, larva of Murky Ground-beetle; *B* head of same; *C*, mandible.

at its formidable jaws, Fig. 20, *b–c*, it is easy to conjecture the fate of many a curculio grub.

Thus here again are found some "bugs" that are friends and not foes, worthy of all the protection that can be afforded them, and well repaying such careful observation of their habits as may be bestowed upon them.

Insect Parasites.

Though large numbers of injurious insects are annually destroyed by those which are purely predaceous upon them, many more succumb to those minute forms which live parasitically within them. A few of these parasites belong to the order *Diptera*, or true flies, but most of them are classed in the order *Hymenoptera*, in which order are also included the saw-flies, ants, wasps, and bees.

Of the half-dozen families of hymenopterous parasites one of the largest and most beneficial is that of the Ichneumon-flies. The illustrations will best show the form and structure of these insects, which the casual

observer will hardly be able to distinguish from other families of the group. But it will be noticed that the fine veins of the wings vary considerably in the different parasites figured, and it is by these that the entomologist is enabled to separate the different groups and often to identify the species at a glance. Both this and the following family are peculiar in having an exceedingly long

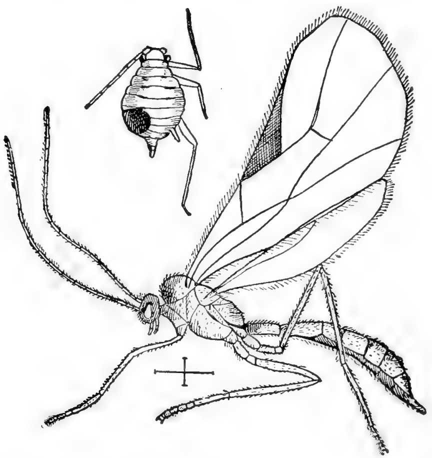

FIG. 21.—A Plant-louse Parasite (*Aphidius granariaphis*), showing above the parasitized louse from which it has issued. (Copied from J. B. Smith)

ovipositor or egg-tube, of which it will be seen that they make a very good use. It is with this extensile tube that the female deftly punctures the skin of some unsuspecting caterpillar, and under it inserts her eggs. In a few days there hatch from these a host of young grubs, which feed upon the juices and tissues of the caterpillar, but are seemingly careful to avoid injuring any of its vital organs, for as soon as the caterpillar reaches its full growth it

changes to a pupa, apparently unaffected. But now the maggots have reached their full size, and each spins up a small silken cocoon inside the pupa, entirely filling up its now dead shell, and instead of a beautiful moth appearing in the spring, from a round hole in the side of the pupa, or cocoon, a horde of small flies are seen to emerge.

Thus large numbers of such pests as the Apple-tree Tent-caterpillar (*Clisiocampa americana*), Bag-worms

FIG. 22.—Maggots of *Pimpla inquisitor*, a parasitic Ichneumon-fly, feeding on a caterpillar which had spun its cocoon and was ready to pupate. (Original.)

(*Thyridopteryx ephemeræformis*), caterpillars of the swallow-tailed butterflies which feed upon parsley, carrots, etc., and a host of others, are consumed by members of this family.

Those belonging to the genus *Ophion* are partial to the large American silkworms which produce some of our largest and most beautiful moths, and difficulty is frequently experienced in rearing a desired number of moths on account of the large per cent of cocoons parasitized.

The species of the family *Braconidæ* are very similar to those of the preceding one, and contain some equally

beneficial insects, feeding as they do upon such pests as the Codling-moth, Web-worms, Plum-curculio grub, Plant-lice, etc. Some of the more common forms of this family belong to the genus *Microgaster*, and their small white cocoons may frequently be seen almost covering one of our large tomato- or tobacco-worms (see page 237), the

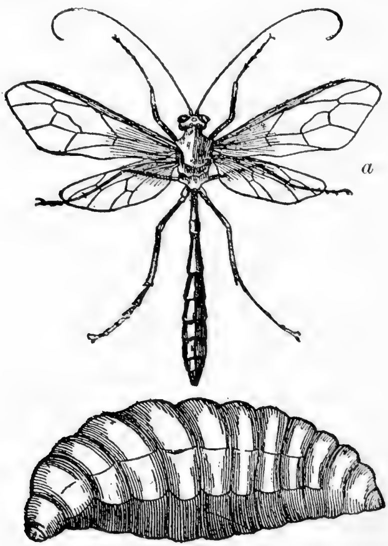

FIG. 23.—The Long-tailed Ophion (*Ophion macrurum*). *a*, adult; *b*, maggot. (After Riley.)

pupæ of which are often known as "horn-blowers." Many mistake these cocoons for the eggs of the worms, and therefore destroy some of their best friends. Though some thus spin their cocoons on the outside of the host, others remain inside of the parasitized insect until the adult fly emerges. Thus dead plant-lice may often be found with a large round hole in the abdomen—the only evidence of

where one of these parasites has emerged. For this reason as a general rule dry, shrunken plant-lice should never be destroyed.

The Chalcis-flies, which comprise another closely related family, are exceedingly minute insects, sometimes not over one one-hundredth of an inch long. They are generally of a metallic black color, and the usual veins of the wings are almost entirely absent. Many of these flies are parasitic upon plant-lice, while a large number of their larvæ live and mature in the eggs of other insects.

Very similar to the Chalcis-flies in their habits of infesting plant-lice and insect eggs are some even smaller insects —in fact the smallest known, the largest being rarely over one twenty-fifth and the smallest only six or seven one-thousandths of an inch in length—with a correspondingly tremendous and unpronounceable name, known to science as the *Proctotrypidæ*.

But enough has been said to indicate the important part which the immense hordes of these apparently insignificant insects play in the economy of Nature, by often clearing off a most dreaded insect pest in a few days almost as if by miracle.

CHAPTER V.

INSECTS INJURIOUS TO THE GRAINS AND GRASSES.

UNDER the above head several common insects which are injurious to almost all of the grains and grasses may be conveniently grouped, thus distinguishing them from those which affect a few or an individual species.

White Grubs (*Lachnosterna spp.*).

Of all the insects attacking cereal crops none are better known than the so-called "white grubs." I say "so-called," for the Englishman has styled this larva the "cockchafer grub," the Frenchman calls it "ver blanc," and the German has named it the "engerling," while here in America the adult beetles are known both as May-beetles, June-bugs, and dor-bugs, and when flying in the windows and buzzing around the ceilings are often termed "pinching-bugs." In Europe white grubs have long been recognized as one of the agriculturist's worst insect foes, and their depredations were noted in this country as early as the middle of the seventeenth century.

Life-history.—As for most of our grain insects, grass land is their favorite haunt, and the female beetle usually lays her eggs in old meadows, though not infrequently in corn land. The eggs, which are glossy white, about one

eighth of an inch long, and broadly oval, are laid early in June and hatch in from 11 to 13 days. The grubs hatching from these feed upon the plant-roots, growing but slowly, as they require a bout two years to become full-

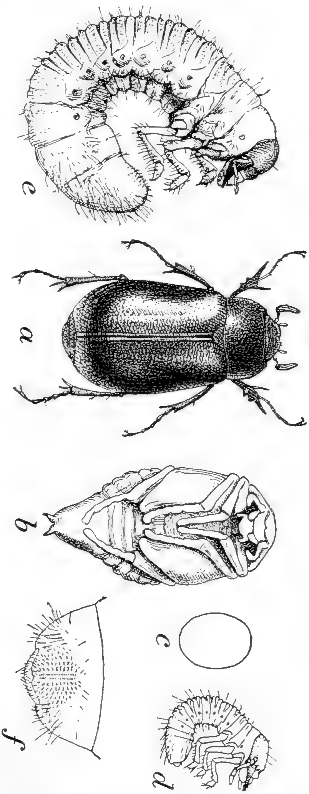

FIG. 24.—*Lachnosterna arcuata*. *a*, beetle; *b*, pupa; *c*, egg; *d*, newly-hatched larva; *e*, mature larva; *f*, anal segment of same from below. *a*, *b*, *e*, enlarged one-fourth; *c*, *d*, *f*, more enlarged. (After Chittenden, U. S. Dept. Agr.)

grown. Meanwhile, however, each grub does its full share of damage, especially to corn and grass, and often to the smaller grains. Its attacks have also long been feared by the growers of strawberries, potatoes, and garden truck,

as well as by nurserymen and greenhouse florists. The grub becomes full-grown in the summer of the second year after hatching from the egg.

It then forms a small oval cell from three to ten inches below the surface of the soil, and here changes to the pupa. The pupal stage lasts slightly over three weeks. Late in August or early in September another transformation takes place and the adult beetle wriggles out of the pupal skin, but remains in the earthen cell until the following spring, when it comes forth fully hardened in May or June. The beetles at once pair, and the females deposit their eggs and soon die. Thus three full years are consumed in the complete life-cycle of each brood.

Injury.—Having seemingly formed a dislike to the light of day from their long subterranean existence, the adult beetles feed and pair entirely at night. The foliage of almost all of the common forest- and shade- and occasionally fruit-trees suffers from their attacks. Injury to maple-trees has been specially observed. About 9 P.M. of an evening early in June, thirty-five beetles were once taken by the writer from a small silver-maple tree about eight feet in height, and they were equally numerous on all of a long row of these trees.

But the grubs and beetles are too common to need description and may be recognized from the figures. It may not, however, be known that the term "white grubs" is generally applied to the larvæ of many distinct species of the genus *Lachnosterna* and one of *Cyclocephala*, which so far as known have practically the same habits, except that the larvæ of the latter genus remain over winter as dormant larvæ and pupate in May.

By cutting off the tap-root and feeding roots of corn,

white grubs have often been responsible for the total or partial failure of large areas of corn land. In 1895 the grubs so injured one twenty-year-old meadow of 250 acres in Illinois that the sod could be rolled up like a carpet over the entire field.

Remedies.—Unfortunately, as regards remedies for this pest little is known. Though eaten by various birds and parasitized by a half-dozen or so insects, yet these natural enemies seem to be of little value for holding the grubs in check. Leaving land in meadow for several years is undoubtedly conducive to their rapid increase; and hence a short rotation in which clover follows grass and which is in turn followed by the small grains before corn will very largely prevent serious damage to the latter crop. Poisoned bran mash such as used for cutworms (see page 217) is reported as having been used successfully against the grubs by scattering it over infested land.

If turned loose in infested grass land, swine will fairly gorge themselves on the grubs, and, prior to plowing grass land for corn, this will be found to be one of the best means for ridding it of grubs. The hogs will also feed as freely upon the beetles which drop to the ground from the trees and hide during the day, and hence they may be of considerable benefit in woodland adjoining infested fields. A flock of chickens or turkeys following the plow or cultivator will also be found to consume not a few of the grubs. In Europe the beetles are systematically jarred from the trees in the early morning by organized bands composed mostly of women and boys, in much the same manner as we "jar" for the Plum-curculio. But such methods, as well as spraying seem hardly practicable in our larger country, except possibly for young orchard-trees, which are often

seriously defoliated. As the beetles remain in the pupal cells over winter and are still tender, not fully hardened, deep fall plowing will destroy a large number of them by breaking open the pupal cells and exposing them to the weather, and by burying or crushing them. But possibly the best method of preventing serious injury by white grubs, and one which will not only be of benefit in securing immunity from the attacks of this as well as many other insect pests, but will also cause less drain upon the soil, is a judicious rotation of crops, avoiding a continual growth of grass in any one field.

Wireworms (*Elateridæ*).

Injury.—The soil has been properly prepared and the field carefully planted. Day after day the anxious farmer awaits the sprouting of the young shoots of grain. But all in vain! Still no signs of growth appear. So, apprehensive that he lose the use of the land, he removes the earth from some of the seed and there finds the kernels of corn or wheat either with a small round hole drilled through them or some "hard, smooth, shining, reddish or yellowish-brown, slender, cylindrical, six-legged larvæ" still devouring the seeds, with their heads firmly embedded in them. If he be a man of any experience, he at once recognizes the work of wireworms and wastes no time in reseeding his field, for of all the insects attacking grain in the seed, these are the most common and destructive. If later on the resown seed secures a start, its growth is exceedingly liable to be stunted by the worms attacking the smaller roots, and it may even be killed when several inches high by their boring through the underground

stalk. All the grains are attacked by wireworms, but wheat and corn suffer most, as well as potatoes, turnips, and many garden crops.

Description.—Wireworms, which are the young of a number of beetles, which, from their habit of snapping

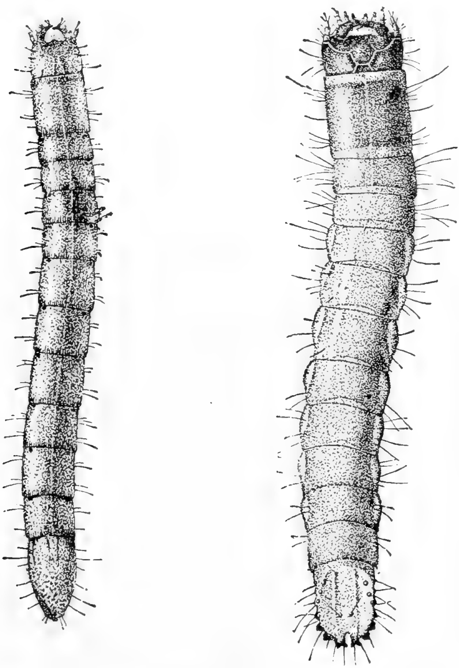

Fig. 25.

The Corn Wireworm (*Melanotus cribulosus*), enlarged $4\frac{1}{2}$ diameters. (After Forbes.)

The Wireworm of *Drasterius elegans,* enlarged seven diameters. (After Forbes.)

their bodies up in the air, are known as "click-beetles," are all more or less like Fig. 25 in general appearance. Although the common wireworms are usually supposed to be of but one kind, upon examination several species will

often be found which may be distinguished by a comparison of the caudal segment with the illustrations (Figs. 27 and 28). The adult beetles are mostly about one-half to three-fourths of an inch long, decidedly flattened, of a dark brown color, with short heads and shield-shaped thoraxes, as in Fig. 26.

Life-history.—Land which has been in grass for several years is their native breeding-ground, and here the eggs

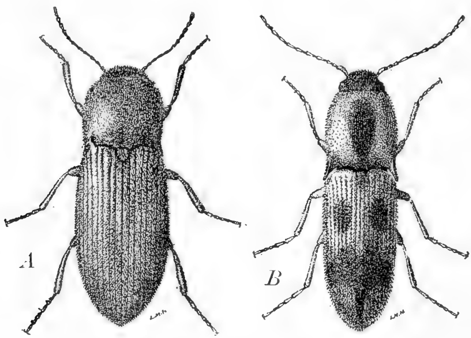

FIG. 26.—*A*, Beetle of Wheat Wireworm; *B*, *Drasterius elegans*, both enlarged about 4 diameters. (After Forbes.)

are deposited. Much concerning the life-histories of these important pests is still unknown, but it seems safe to assert that the larvæ require from three to five years to become full-grown. Thus the second year after grass land has been planted in grain is that in which the worst injury occurs, and this is especially true with corn, which covers the ground less completely than do the smaller grains. The larvæ become full-grown in midsummer, form a small earthen cell, and there transform to the pupæ. Three or four weeks later the adult beetles shed the pupal skin, but only a few of them make their way to the surface during

the fall, the most of the brood remaining in the pupal cells as partially hardened beetles until the following spring.

Means of Combating. — Remedies galore have been advised for these insects, almost every farmer having his

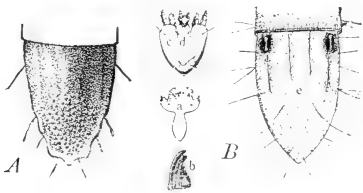

FIG. 27.—*A*, last segment of *Melanotus communis*, dorsal view. (After Forbes.) *B*, the Wheat Wireworm, *Agriotes mancus*. *a*, *b*, *c*, *d*, details of mouth-parts, enlarged. (After Slingerland.)

favorite expedient, but in recent years a careful testing has shown that a satisfactory remedy or preventive for wireworms is yet to be discovered. Professors Comstock and

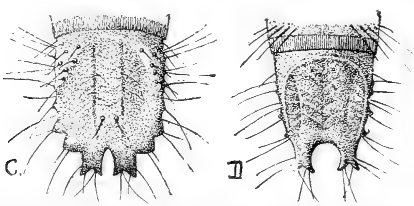

FIG. 28.—*C*, caudal segment of the Wireworm of *Drasterius elegans* *D*, caudal segment of the Wireworm of *Asaphes decoloratus*, much enlarged. (After Forbes.)

Slingerland performed extensive experiments for nearly three years in attempting to successfully combat these insects by (1) the protection of the seed, and (2) the destruction of the larvæ by (*a*) starvation in clear fallow

and supposedly immune crops, and (*b*) by the use of insecticides and fertilizers. But all the remedies or preventives tested resulted in failure, and this has been the experience of several other leading entomologists. It was ascertained, however, that they may be more or less checked by destroying the beetles. This can be done both by fall plowing or by trapping. By plowing late in summer and keeping the earth stirred for a period of a month or so, large numbers of the newly transformed beetles which do not become fully hardened until spring, and pupæ, will be destroyed. When the wireworms are numerous in restricted areas, as they often are on spots of low moist land, they may be effectually trapped with but little labor by placing under boards bunches of clover, or sweetened cornmeal poisoned with Paris green.

A short rotation of crops, in which land is never allowed to remain in grass for any length of time, will undoubtedly secure comparative immunity from serious attack.

The Chinch-bug (*Blissus leucopterus* Say).*

Though individually insignificant, when assembled in countless myriads Chinch-bugs have doubtless been of greater injury to the farmers of the Mississippi Valley than any other insect attacking grain crops, and are responsible for hundreds of millions of dollars' loss.

Distribution.—This insect may be found over all the eastern United States to the Rockies, and in restricted

---

* See "The Chinch-bug," F. M. Webster, Bulletin 15, n. s., Div. Ent., U. S. Dept. Ag.; Dr. S. A. Forbes, 12th, 16th, and 20th Repts. St. Ent. Illinois.

localities in Cuba, Central America, Panama, Lower and Central California; but the area in which it has been most injurious lies in the Central and North Central States. During the last five years, however, its attacks have been increasingly wide-spread in Ohio and Kentucky, and in August, 1898, some damage was done by it in Pennsylvania and New York.

Description.—The adult bug is about one-fifth of an inch long, with a black body. Its white wings lie folded over

FIG. 29.—The Adult Chinch-bug (*Blissus leucopterus* Say) enlarged. (After Riley.)

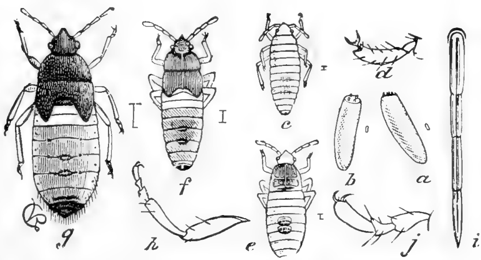

FIG. 30.—*a*, *b*, eggs magnified and natural size; *c*, young nymph; *e*, second stage of nymph; *f*, third stage; *g*, full-grown nymph or pupa; *d*, *h*, *j*, legs; *i*, beak through which the bug sucks its food. (After Riley.)

each other on the back of the abdomen, and are marked by a small black triangle on their outer margins, while the bases of the antennæ, or feelers, and the legs are red. The young bugs are mostly red, but vary in the different stages.

Life-history.—During the winter the bugs hibernate in clumps of grass and under boards and rubbish. With the first warm days of spring they come forth and spread about the neighboring wheat-fields, but there do little harm. Very soon they pair, and the females, each of which is

Fig. 31.—Corn-plant two feet tall infested with Chinch-bugs. (After Webster, Bull. 15, n. s., Div. Ent., U. S. Dept. Agr.)

capable of laying 150 eggs, commence to deposit them either upon the roots or bases of the stalks. This occurs from the middle of April until the first of June, depending upon the latitude and weather, and the eggs hatch in from two to three weeks. The nymphs often severely injure the small grains, and are full-grown about the time of harvest. As the wheat is harvested they spread to oats and soon to corn, but, curiously enough, though the adults have wings they prefer to travel from field to field on foot, much like Army-worms, and were it not for this fact we would be at a loss how to cope with them. Another lot of eggs are now laid under the unfolding leaves of the corn, and the young nymphs emerge in about ten days. This brood lives upon corn, and when full-grown is that which hibernates over winter. South of the latitude of southern Illinois there is often an unimportant third brood. The most extensive injury is done by the mature nymphs and adult bugs of the first brood. Though no means is known for preventing the ravages of this brood in the small grains, every effort should be made to defend the young corn from its attacks, for, with the innumerable little beaks of the adult insects sucking out its life, it soon succumbs when they are reinforced by the largely multiplied numbers of the second brood.

Methods of Prevention and Destruction.—During the migration from the small grains to corn seems to be practically the only time when this pest may be successfully combated. Just before harvest a narrow strip should be plowed around the corn-field and this thoroughly pulverized by harrowing and rolling, and then reduced to as fine a dust as possible by dragging over it a brush composed of dead limbs, or whatever contrivance is most convenient.

A log or block should now be dragged through this strip in such a manner as to form a deep furrow, with the inclination of its side next the corn as steep as possible. In attempting to climb this barrier, the dust will slide from under the bugs and large numbers of them will accumulate in the furrow, where, on a clear day, they will soon be killed by the heat if the temperature of the air be over 88 degrees Fahrenheit (the soil will then be 110 degrees Fahr.). The furrow may be kept clean by redragging the log through it as often as necessary. If the weather be cooler, the bugs should be further trapped by sinking holes with a post-hole digger about one foot deep every ten or twelve feet in the furrow. Large quantities will soon accumulate in the holes, and may be there crushed or killed with coal-tar or kerosene.

Of course a sudden dash of rain will destroy such a furrow, and the bugs will then at once march on to the corn-field. In such an emergency a narrow strip of coal-tar, about the size of one's finger, should be run around the field a few feet inside the former furrow, with post-holes dug as before upon the outside of the line. Disliking the smell of the tar, the bugs will again fall into the traps and may then be destroyed. As many strips may be made along the outer rows of corn as seem necessary to prevent their further progress. These strips of tar should be freshened whenever dust, straw, or rubbish has crossed them at any point. In this manner one Illinois farmer protected over 300 rods with less than a barrel of tar. That this method is practicable and efficient was thoroughly demonstrated by Prof. W. G. Johnson in a series of experiments in Illinois, in the report of whose work Prof. Forbes says: "In short, the success of this

field experiment, tried under very difficult conditions, was substantially complete, and the value of this method of contest with the Chinch-bug seems established beyond controversy."

Extensive experiments have been made in Illinois and Kansas in the use of the Muscardine fungus—*Sporotrichum globuliferum*—against the Chinch-bug. Though the results have often seemed to indicate its use to be profitable, yet it has never so commended itself—even to entomologists—as of sufficient value to be brought into general use, and its value must still be considered as largely problematical.

If the bugs have already become numerous in the outer rows of corn, most of them may be destroyed by a spray of kerosene, which, with a tar strip, will effectually protect the remainder of the field. Such a spray may be either (1) in the form of an emulsion, composed of a "stock solution" of one pound of soap, one gallon of water, and two gallons of kerosene, prepared in the usual manner, and diluted with fifteen quarts of water; or (2) may be merely a mechanical mixture of about one part kerosene to four parts of water (20 per cent), which can be formed only by pumps with a special kerosene attachment, and which are now very largely doing away with the use of the soap emulsion. About a teacupful of this spray to a hill will be ample, and at this rate an acre will require about 60 gallons at a cost of about one dollar.

In case of serious attack by the Chinch-bug the farmer must at once prepare to devote to combating it the time of as many hands as his interests may require; for the above methods require constant and personal supervision, but, where carefully tested by practical farmers, have been

found to be the best and only means of preventing the loss of their crops.

Locusts (*Acrididæ*).

Plagues of destructive locusts—or what the American farmer terms grasshoppers—have been recorded since the dawn of history. In America the worst devastation has been done by flights of the Rocky Mountain or Migratory Locust (*Melanoplus spretus* Thos.), which swooped down upon the States of the western part of the Mississippi Valley in the years 1873–76 like a veritable horde of mountain robbers. Since then they have several times done considerable injury in restricted localities, but never in such numbers or so generally as to cause apprehension of another "grasshopper plague."

Concerning their recent distribution, numbers, and destructiveness, Mr. W. D. Hunter reported after the season of 1897: "There was, this season, a general activity of this species throughout the permanent breeding region greater than at any time in many years. This was brought about by a series of dry years, which have resulted in the abandonment of farms in many places. It is, of course, well understood that the absence of serious damage since 1876 has been partially due to the settling up of valleys in the permanent region. I wish to make it clear, however, that the dryness is the primary and the abandoning a secondary cause."

The Rocky Mountain Locust.

Let us first consider this the most injurious species, as the other locusts differ from it in but few essential points other than in being non-migratory.

To correctly understand its habits the reader should first divide the area which this species affects into three parts. Of these the (1) "Permanent Region, including the highlands of Montana, Wyoming, and Colorado, forms the native breeding-grounds, where the species is always

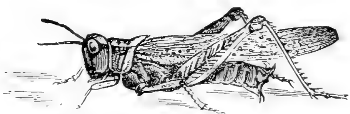

FIG. 32.—Rocky Mountain Locust.

found in greater or less abundance." * (2) The Subpermanent Region, including Manitoba, the Dakotas, and western Kansas, is frequently invaded. Here the species may perpetuate itself for several years, but disappears from it in time. (3) The Temporary Region, including the States bordering the Mississippi River on the west, is that only periodically visited and from which the species generally disappears within a year.

Spread.—When for various reasons the locusts become excessively abundant in the Permanent Region they spread to the Subpermanent Region, and from there migrate to the Temporary feeding-grounds. It is the latter area which suffers most severely from their attacks, but, fortunately, they generally do not do serious injury the next year after a general migration. In the Subpermanent Region their injuries are more frequent than in the Temporary, but hardly as severe or sudden as farther east. Immigrating from their native haunts, flights of the grasshoppers usually reach southern Dakota in early summer, Colorado, Nebraska, Minnesota, Iowa, and western Kansas

* Bull. 25, U. S. Dept. Ag., Div. Entomology. C. V. Riley.

during midsummer, and southeastern Kansas and Missouri during late summer, appearing at Dallas, Texas, in 1874,

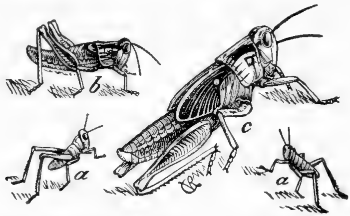

FIG. 33.—Rocky Mountain Locust. Different stages of growth of young.

about the middle of October, and even later in 1876. As thus indicated, the flights are in a general south to south-

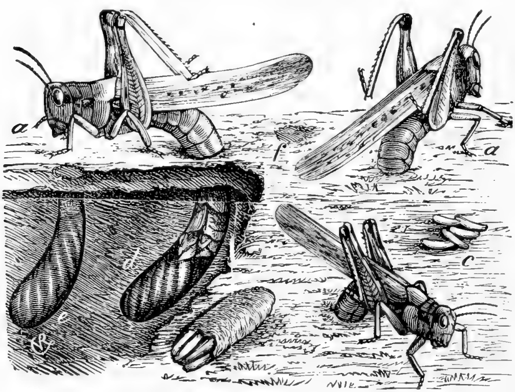

FIG. 34.—Rocky Mountain Locusts. *a, a, a,* females in different positions, ovipositing; *b,* egg-pod extracted from ground, with end broken open; *c,* a few eggs lying loose on ground; *d, e,* show the earth partially removed, to illustrate an egg-mass already in place and one being placed; *f* shows where such an egg-mass has been covered up. (After Riley.)

easterly direction, while west of the Rockies they descend to the more fertile valleys and plains, but without any such regularity as east. While the rate of these flights is

variable and entirely dependent upon local weather conditions, twenty miles a day may be considered a fair average. The flights are more rapid and more distance is covered in the early part of the season, when, while crossing the dry prairies, a good wind will often enable them to cover 200 to 300 miles in a day. As they first commence to alight in their new feeding-grounds their stay is limited to but two or three days, but later in the season it is considerably lengthened, and, after being once visited, in an infested country swarms will be seen to be constantly rising and dropping during the middle of the day.

Life-history.—Over all the infested area, and while still sweeping it bare of crops and vegetation, the females commence to lay their eggs, and continue to deposit them from the middle of August until frost. For this purpose "bare sandy places, especially on high, dry ground, which is tolerably compact and not loose," are preferred. "Meadows and pastures where the grass is closely grazed are much used, while moist or wet ground is generally avoided."

In such places the female deposits her eggs in masses of about thirty. These are placed about an inch below the surface in a pod-like cavity, which is lined, and the eggs covered by a mucous fluid excreted during oviposition. From two to five hours are required for this operation, and an average of three of these masses is deposited during a period of from six to eight weeks.

As the time of ovipositing varies with the latitude, so the hatching of the eggs occurs from the middle or last of March in Texas till the middle of May or first of June in Minnesota and Manitoba. Until after the molt of the first skin, and often till after the second or third molt, the young nymphs are content to feed in the immediate

vicinity of their birth. But upon such food becoming scarce they congregate together and in solid bodies, sometimes as much as a mile wide, march across the country, devouring every green crop and weed as they go. During cold or damp weather and at night they collect under rubbish, in stools of grass, etc., and at such times almost seem to have disappeared; but a few hours of sunshine brings them forth, as voracious as ever. When, on account of the immense numbers assembled together, it becomes impossible for all to obtain green food, the unfortunate ones first clean out the underbrush and then feed upon the dead leaves and bark of timber lands, and have often been known to gnaw fences and frame buildings. Stories of their incredible appetites are legion; a friend informs me that he still possesses a rawhide whip which they had quite noticeably gnawed in a single night!

By mathematical computation it has been shown that such a swarm could not reach a point over thirty miles from its birthplace, and as a matter of fact they have never been known to proceed over ten miles.

As the nymphs become full-grown they are increasingly subject to the attacks of predaceous birds and insects, insect parasites, fungous and bacterial diseases, as well as being largely reduced by the cannibalistic appetites of their own numbers. When the mature nymphs transform to adult grasshoppers and thus become winged, large swarms are seen rising from the fields and flying toward their native home in the Northwest. This usually takes place during June and early July in the North, and as early as April in Texas, so that it is frequently impossible to distinguish the broods of the temporary region from the incoming brood which has migrated from the perma-

nent region. Although the eggs for a second brood are sometimes laid, these seldom come to maturity, and the species is essentially single-brooded.

Enemies.—As before mentioned, large numbers of the nymphs are destroyed before reaching maturity by their natural enemies. Among these a minute fungus undoubtedly kills many of those already somewhat exhausted, especially during damp weather. Almost all of our com-

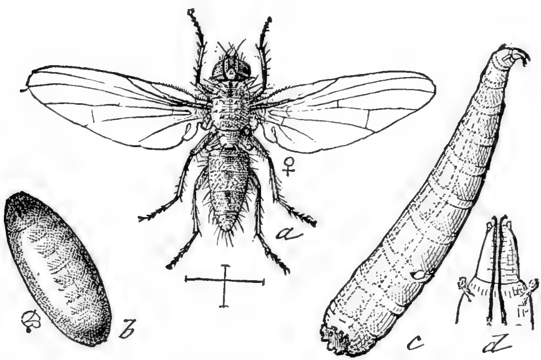

FIG. 35.—*Anthomyia*, egg-parasite. *a*, fly; *b*, puparium; *c*, larva; *d*, head of larva. (After Riley.)

mon birds, as well as many of the smaller mammals, are known to feed quite largely upon them.

A small red mite (*Trombidium locustarum* Riley), somewhat resembling the common Red Spider infesting greenhouses, is often of great value not only in killing the nymphs by great numbers of them sucking out the life-juices of the young hopper, but also in greedily feeding upon the eggs.

The maggots of several species of Tachina-flies are of considerable value in parasitizing both nymphs and adult locusts. Their eggs are laid on the neck of a locust, and,

upon hatching, the maggots pierce the skin and live inside by absorbing its juices and tissues. When full-grown the maggots leave the locust, descend into the earth, and there

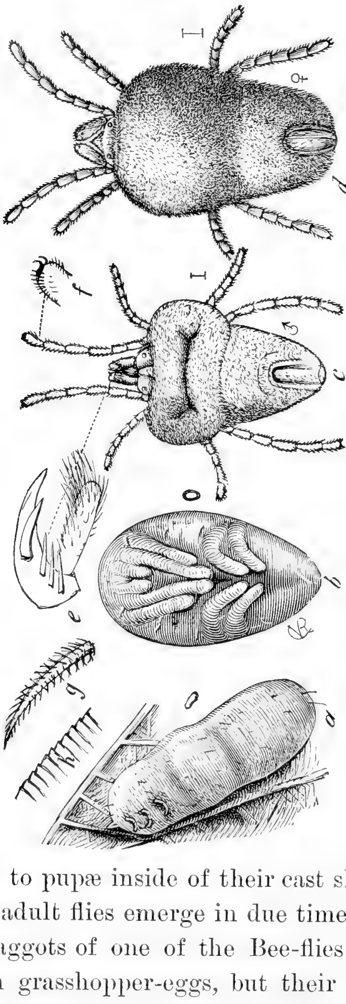

FIG. 36.—*Trombidium locustarum*, or Locust-mite. *a*, the larva as seen on locust's wing; *c*, male mite; *d*, female, the two latter appearing as when egg-destroyers—all greatly enlarged. (After Riley.)

transform to pupæ inside of their cast skins, and from the pupæ the adult flies emerge in due time.

The maggots of one of the Bee-flies (*Systœchus oreas*) feed upon grasshopper-eggs, but their life-history is not

fully known. The common Flesh-fly (*Sarcophaga carnaria* Linn.), Fig. 39, is also very destructive, though largely a scavenger.

Fig. 37.—Tachina-fly. (*Exorista leucaniæ* Kirk). (After Riley.)

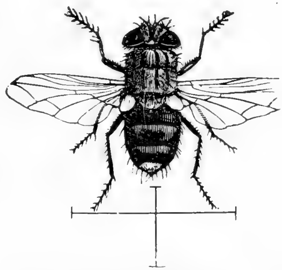

Fig. 38. — Tachina-fly. (*E. flavicauda* Riley). (After Riley.)

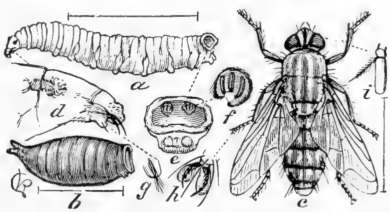

Fig. 39.—Common Flesh-fly (*Sarcophaga carnaria* Linn.). *a*, larva; *b*, pupa; *c*, fly. Hair-lines show natural size. (After Riley.)

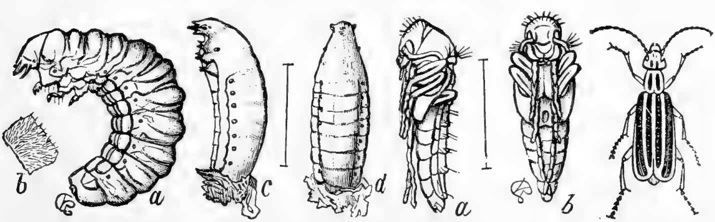

Fig. 40.—Various stages of a Blister-beetle (*Epicauta vittata*). (After Riley.)

But of all the insects attacking locusts, the Blister-beetles, which, unfortunately, are often known to us as very injurious to various garden crops, are probably of the

most value. The female beetle deposits from four to five hundred of her yellowish eggs in irregular masses in loose ground, and in about ten days there hatch from these eggs some "very active, long-legged larvæ, with huge heads and strong jaws, which run about everywhere seeking the eggs of locusts." Each of these larvæ will consume one of the masses or about thirty eggs. The subsequent life-history of these insects is very complicated on account of their peculiar habits, but the various stages are shown in Fig. 40.

The Lesser Migratory Locust.

Besides the Rocky Mountain Locust there is only one other species that truly possesses the habit of migrating, though to a far lesser extent, and which is therefore known as the Lesser Migratory Locust (*Melanoplus atlantis* Riley). It is considerably smaller than its western relative and somewhat resembles the Red-legged Locust both in size and appearance. The species of very widely distributed, occurring from Florida to the Arctic Circle east of the Mississippi, and on the Pacific slope north of the 40th parallel to the Yukon. The habits and life-history of the species are in all essentials practically the same as of the former species except that they have no particular breeding-grounds. Injuries by this grasshopper were first noticed in 1743, almost seventy-five years before the first record of the Rocky Mountain Locust, and since then they have done more or less serious damage in some part of the territory inhabited every few years.

Non-migratory Locusts.

There are several species of locusts which, though lacking the migratory habit, and thus being more easily controlled, often become so numerous as to do serious damage

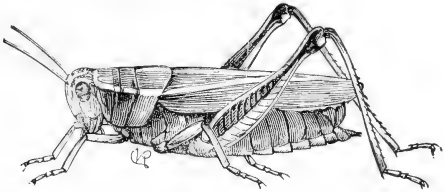

FIG. 41.—The Two-striped Locust (*Melanoplus bivittatus* Scud.). (After Riley.)

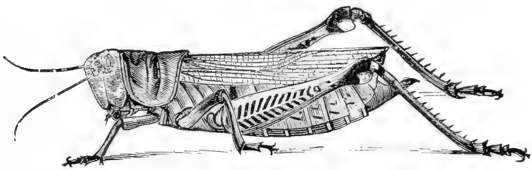

FIG. 42.—The Differential Locust (*Melanoplus differentialis* Thos.) (After Riley.)

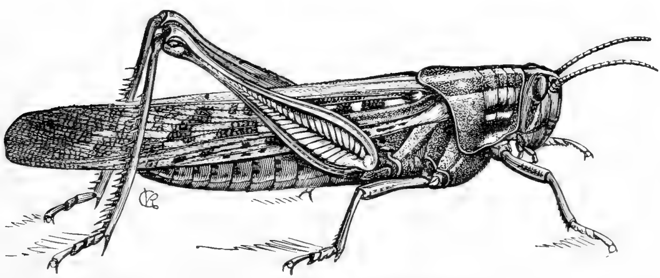

FIG. 43.—The American Acridium (*Schistocerca americana* Scud.). (After Riley.)

FIG. 44.—Red-legged Locust (*Melanoplus femur-rubrum* Harr.). (After Riley.)

over limited areas. Both as regards the regions inhabited, its habits, and life-history, the common Red-legged Locust (*Melanoplus femur-rubrum* Har.) hardly differs from the last species and is often found in company with it. It is non-migratory, however, and though its injuries are thus entirely local, they are often of considerable importance.

Records of locust-plagues in California date back as far as 1722. Many of them were doubtless due to the Cali-

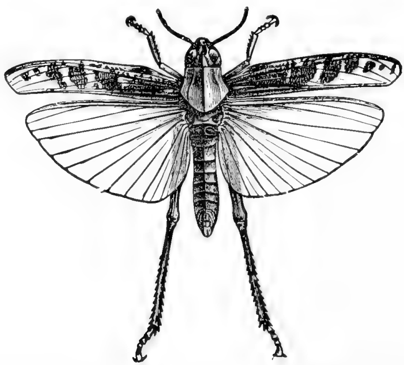

FIG. 45.—The Pellucid Locust (*Camnula pellucida* Scud.). (After Emerton.)

fornia Devastating Locust (*Melanoplus devastator* Scud.), and in the last invasion of 1885 this species outnumbered all others seven to one. Resembling the last two species in size and markings, the habits and life-history of this species are also supposed to be similar to them, though they have not as yet been thoroughly studied.

Together with the last species the Pellucid Locust (*Camnula pellucida* Scud.) has been largely responsible for the losses occasioned by locusts in California, and has also been found in New England, but not noted there as specially destructive.

Considerably larger than the preceding species are the Differential Locust (*Melanoplus differentialis* Thos.) and the Two-striped Locust (*Melanoplus bivittatus* Scud.), of which the former is peculiar to the central States of the Mississippi Valley, Texas, New Mexico, and California,

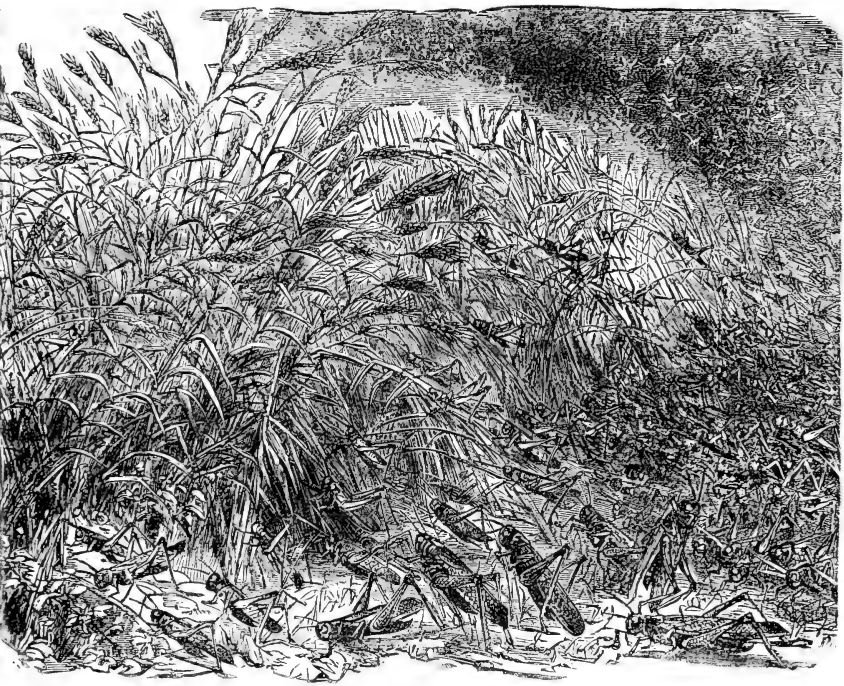

FIG. 46.—A Swarm of Grasshoppers Attacking a Wheat-field. (After Riley.)

while the latter has a more extended range from Maine to Utah and as far south as Carolina and Texas. These two differ from the smaller species in laying only one or two masses of eggs, and the eggs of *differentialis* have often been found placed under the bark of logs, but otherwise their habits are very similar. The Two-striped Locust is

characterized by two yellowish stripes extending from the eyes along the sides of the head and thorax to the extremities of the wing-covers, and is probably the species most commonly observed by the farmer.

The Differential Locust.

An unusually severe outbreak of the Differential Locust occurred in Mississippi and Louisiana in 1899 and 1900 and was quite fully investigated by Prof. H. A. Morgan, and interestingly reported upon by him.* It seems that outbreaks of this grasshopper invariably occur immediately after an overflow of the Mississippi or crevasses through the levees, which inundate the surrounding country, causing a rank growth of vegetation and rendering the land unfit for cultivation for a season or two, during which time the grasshoppers have every opportunity for rapidly increasing in abnormal numbers. "Should heavy rains prevail during May and June of the season immediately following the crevasse, nothing is heard of the ravages of grasshoppers; but should dry summers follow, the conditions for grasshopper propagation and development are much more favorable and complaints are common." "The habits of young grasshoppers to seek the soil-crevices during rain results in the burial of millions beyond the hope of resurrection. This, with the development and propagation of fungous diseases among the nymphs, are the most potent natural agencies which destroy grasshoppers during wet summers."† In 1899 thousands of acres of cotton, corn, and other crops were totally destroyed

* See Bulletin 30, n. s., Div. Ent., U. S. Dept. Agr., pp. 7–33.

† Morgan, l. c., p. 33.

or seriously injured, and only saved by a most persistent fight against the locusts.

The eggs are deposited in a single mass of from 103 to 132, mostly from August 10 to September 15. The young hatch from the eggs during the first three weeks of May and, after molting five times, become full-grown by the last week in June. They mate about the middle of July, and the eggs are laid a few weeks later.

Our largest American locust, the American Acridium (*Schistocerca americana* Scud.), is practically confined to the Southern States from the District of Columbia to Texas, and thence south through Mexico and Central America, being rarely found in the North. This species is essentially a tropical one, and has often been exceedingly destructive, being especially so in 1876 in Missouri, Tennessee, North Carolina, Georgia, and southern Ohio.

Remedies and Preventives.—All of our destructive locusts having essentially the same life-history and habits except that of migrating, methods of combating them will apply almost equally well to all, but must, of course, be judiciously determined according to existing local conditions.

Destruction of the Eggs.—Of first importance in this warfare is the destruction of the eggs. In Europe, where labor is cheap, this is often done by hand-picking. That would hardly do in a western corn-field or wheat-ranch. They may, however, be quite successfully destroyed either by fall plowing or harrowing. In harrowing, "the object should be not to stir deeply, but to pulverize the soil as much as possible to about the depth of one inch. Where the cultivator is used, it would be well to pass over the ground again with a drag- or brush-harrow for this pur-

pose.* In this way many of the egg-pods may be broken up or left exposed on the surface. Prof. Morgan has shown that of eggs in land thus treated 80 per cent failed to hatch.

By plowing in the fall to a depth of about eight inches the same result is more surely accomplished by turning the eggs under to such a depth that the young hoppers upon hatching are unable to reach the surface. This will be made more effectual by then harrowing and rolling, so as to compact the surface as much as possible. Such plowing might even be profitable if done in very early spring were it then followed by the usual spring showers, but in all probability it would be better to wait till the young are hatching, when large numbers of them can be buried by plowing infested fields in a square from the outside inward.

Destroying the Nymphs.—Burning.—After hatching every effort should be made to destroy the locusts while still young. The burning of straw or hay stubble, dead grass, or rubbish, where it is present in sufficient quantities, or even, if need be, by augmenting such with rows of straw, is one of the best methods, especially on cold days when the young hoppers are congregated under such materials. Several machines have been devised both for burning and crushing the nymphs, but all are of doubtful utility.

Crushing.—When, however, the surface of the ground is smooth and hard, a heavy roller will crush large numbers of the nymphs while they are still young, especially in the morning and evening.

---

* Riley, Bull. 25, l. c.

Ditching.—Of the various means devised for trapping the nymphs "ditching" is one of the best, and is of especial advantage when the crops become too large for the effective use of other methods. Simple ditches two feet wide and two feet deep, with nearly perpendicular sides, form effectual barriers to young grasshoppers. The sides next to the field to be protected must be kept finely pulverized and not allowed to become washed out or hardened. This may be done by a brush composed of dead branches

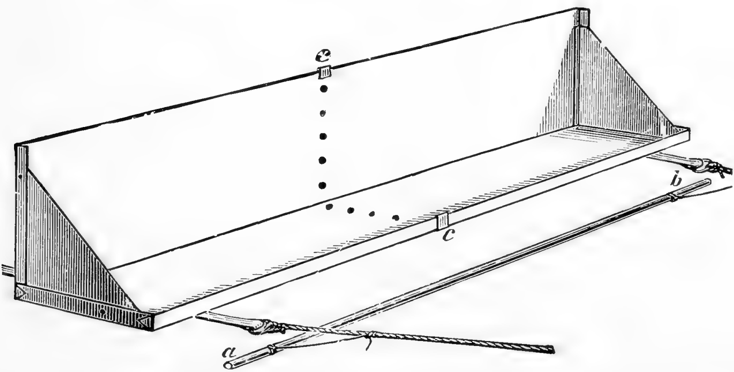

FIG. 47.—Simple Coal-oil Pan or Hopperdozer. (After Riley.)

being hauled through the ditch, which has been dug in a strip of finely pulverized soil. The young locusts tumble into the ditch, and, failing to climb the steep and slippery sides, die there, from their exertions and the heat, in large numbers. To avoid too great an accumulation, pits should be sunk in the ditch at short intervals, in which most of them will accumulate, and where they may be easily buried. It would seem that grasshoppers would be able to leap across such a small obstacle, but as a matter of fact, like the Chinch-bugs, which might fly across, they very seldom do so.

Spraying Ditches.—Prof. Morgan states that "upon river plantations many open ditches are indispensable, and when rains are sufficient to keep them filled or partly filled with water they serve a most excellent purpose in the destruction of the young grasshoppers."

"The experience of spraying ditch-banks soon developed the method of damming water in the ditches and covering the surface with coal-oil or kerosene emulsion. Before and after rains the ditches were dammed and the water

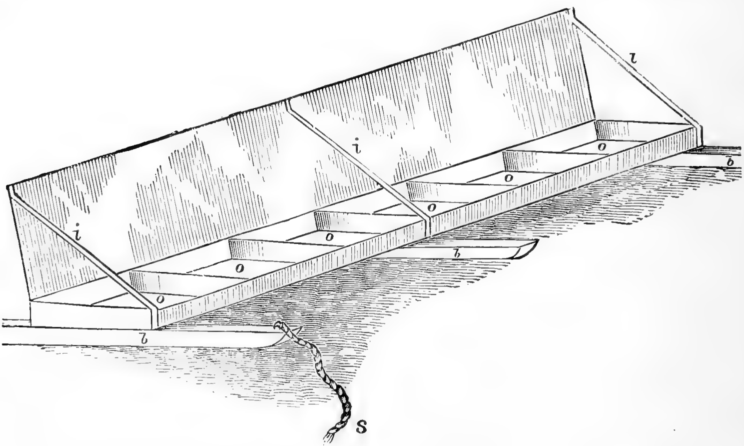

FIG. 48.—The Price Oil-pan or Hopperdozer. (After Riley.)

covered with a 12 per cent coal-oil emulsion. The young grasshoppers were then driven into the ditches, with the result that very few, if any, escaped. In this way a single application of oil would last several days, as many millions may easily float upon the water of a ditch not more than two feet wide. Unless the grasshoppers are scattered too far from the ditch-banks no difficulty is experienced in getting them to move in the direction of the oiled water on account of the 'homing' instinct."

FIG. 49.—Two Hopperdozers, tied together, at work. (After Lugger, Bull. 43, Minn. Agr. Exp. Sta.)

Hopperdozers.—One of the methods most extensively tried for the destruction of the nymphs upon small or young crops is by the use of crude kerosene or coal-tar in one of the so-called "hopperdozers." "The main idea embodied in these contrivances is that of a shallow receptacle of any convenient size, provided with high back and sides, mounted either on wheels or runners. If the pan is larger than, say, three feet square, it is provided with transverse partitions, which serve to prevent any slopping of the contents (in case water and oil are used) when the device is subject to any irregular motion. On pushing these pans, supplied with oil, over the infested fields, and manipulating the shafts or handles so as to elevate or depress the front edge of the pan, as may be desired, the locusts are startled and spring into the tar or oil, when they are either entangled in the tar and die slowly, or, coming in contact with the more active portion of the oil, expire almost immediately. A good cheap pan is made of ordinary sheet iron, eight feet long, eleven inches wide at the bottom, and turned up a foot high at the back and an inch high in the front. A runner at each end, extending some distance behind, and a cord attached to each front corner, complete the pan at a cost of about $1.50 (Fig. 47). We have known of from seven to ten bushels of young locusts caught with one such pan in an afternoon. It is easily pulled by two boys, and by running several together in a row, one boy to each rope, and one to each contiguous pair, the best work is performed with the least labor." Larger pans may be drawn by horses. The oil is best used on the surface of water, from which the insects are removed with a wire strainer. Various modifications of this apparatus have been devised, but the more simple

ones seem to be fully as effective as those more complicated for which fancy prices are charged for royalty.

Destroying the Adults.—The destruction of the winged insects is an entirely hopeless task, for, though even large numbers are caught, so many will remain that the damage done the crops would be but very slightly diminished. One of the most promising means for averting the swarms of winged migratory locusts from alighting in the fields is by a dense smudge, in which some foul smelling substances are placed. Where strictly attended, and with favorable winds, this has often proved highly successful. To accomplish the best results farmers over an extensive area should combine in its use.

The South African Fungus.—In 1900 Prof. Morgan made a test of a fungous disease which had been found to destroy large numbers of grasshoppers in South Africa, to determine whether, after starting it by artificial propagation, it would spread sufficiently to destroy any considerable number of locusts. The weather was favorable, rains being frequent. Early in August it was found that "over the areas where the liquid infection was spread diseased hoppers were abundant." "As many as a dozen dead grasshoppers could be found upon a single plant, and some upon nearly every weed on ditch-banks where grasshoppers were numerous. From the centres of infection great areas had become inoculated, spreading even beyond the plantations first infected." The property upon which it was placed became thoroughly infected with the fungus. Strangely, though many other species of grasshoppers were abundant, only the Differential was killed by it. Dr. Howard states that this disease has also spread and done effective work in Colorado.

Poisoning.—A mash composed of bran, molasses, water, and arsenic or Paris green, which has been extensively used for cutworms, was found to be quite successful in the experiments of Mr. D. W. Coquillet in the San Joaquin Valley, California, during 1885, for protecting orchards, vineyards, gardens, etc., and might even be of some value for grain crops. Two pounds of Paris green, twenty-five pounds of bran, barely moistened with water and cheap molasses, will be about the correct proportion. It should be placed in the fields, a tablespoonful to each plant or vine. At this rate the cost per acre of vineyard, including labor, will not exceed fifty cents. The poison acts slowly, but if judiciously used will be found very effective, especially for the non-migratory forms. In Texas the mash has been found satisfactory in destroying the grasshoppers attacking cotton. One planter* writes: "We are successfully using arsenic (for grasshoppers) at the following rates: 10 pounds of wheat bran, 1½ gallons sorghum molasses, 1 pound arsenic. Make a thick mash, sow broadcast on infected ground, and it will surely kill them. I used 40 pounds last year and made 49 bales of cotton. My neighbors did not do anything and entirely lost their crop." However, Prof. Morgan concluded that "the mash cannot be relied upon in severe outbreaks, such as occurred in the delta, but may be used in limited attacks where the area affected would not warrant the more aggressive methods."

---

* S. D. Harwell, Putnam, Callahan Co., Tex., Bull. 30, n. s., Div. Ent., U. S. Dept. Agr., p. 96.

The Army-worm (*Leucania unipuncta* Haworth).

Almost every year from some portion of this large country reports are received of the ravages of armies of worms sweeping over the grain-fields, like a horde of Vandals. Invariably, also, there has not been a single attack in the infested locality for a number of years, so that the farmer is at a loss to do anything to protect his crops, and by the time information can be received from an entomologist a large portion of them will already have been destroyed. Thus previous knowledge of the habits and remedies for these insects may be of value to him when injury by them is threatened.

Being a species native to this country, these worms may almost always be found east of the Rockies in low, rank growths of grass, which form their habitual breeding-grounds. Yet, though the moth is widely distributed, its chief injuries have been in belts from eastern Iowa to Maine, from northern Texas to northern Alabama, and east of the Blue Ridge Mountains to northern North Carolina. Even in these regions, however, the worms have never been recorded as injurious for two successive years, and the only recent wide-spread outbreaks have been in 1861, 1875, 1880, and 1896, though serious injury is almost annually done in restricted localities. Only when their usual feeding-places are exhausted, or when through favorable climatic conditions or the destruction of large numbers of the parasites which hold them in check, they increase in abnormal numbers, do they assume the marching habit and mass in armies.

Life-history.—In the North there are usually three broods each season, and the insects pass the winter as half-

grown caterpillars; but in the South there may be as many as six broods, and the moths often hibernate over winter, laying eggs early in the spring. In the Northern States these young worms mature, change to pupæ, and from them the adult moths appear early in June, the May broods rarely doing serious injury. The female moths now lay their small yellowish eggs in rows of from ten to

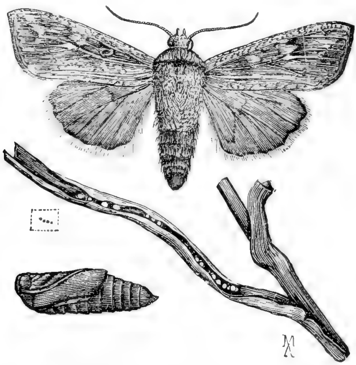

FIG. 50 —Army-worm Moth (*Leucania unipuncta*), pupa, and eggs in natural position in a grass-leaf. Natural size. (After Comstock.)

fifty, inserting them in the unfolded bases of the grass-leaves, and covering them with a thin layer of glue. Over seven hundred may be deposited by one female, and thus it is that the myriads of young worms appear when they hatch in about ten days, and form the destructive army of early July. The worms usually feed entirely at night, and thus whole fields will often be ruined before they are discovered, though a few generally feed during the day, as they all do during cloudy weather. The leaves and stalks of the grains and grasses form their favorite food, the heads usually being cut off, but various garden crops have frequently been seriously injured. As a rule clover

is untouched, but even that is not always exempt. In from three to four weeks the worms become mature and are then about one and one-half inches long, of a dark-gray or dingy-black color, with three narrow, yellowish stripes above, and a slightly broader and darker one on each side, altogether much resembling cutworms, to which they are nearly allied. They now enter the earth and there transform to pupæ, from which the adult moths come forth in about two weeks. These again lay eggs for a brood of worms which appear in September, but are rarely very injurious. The moths developing from this last brood either hibernate over winter or deposit eggs, the larvæ from which become partially grown before cold weather sets in.

The moths very often fly in windows to lights, and are very plain little "millers" The front wings are of a clay or fawn color, specked with black scales, marked with a darker shade or stripe at the tips, and a distinct white spot at the centre—on account of which they were given the specific name *unipuncta.* The hind wings are somewhat lighter, with blackish veins and darker margins.

Enemies.—Were it not for other insects which prey upon the worms, the army habit would undoubtedly be assumed much more often; but ordinarily these very efficiently reduce their number, and Dr. L. O. Howard has recorded two instances in which armies of worms were practically destroyed by them. Large numbers are always destroyed by the predaceous ground-beetles and their larvæ, but their most deadly enemies are two small Tachina-flies. These lay from half a dozen to fifty eggs upon a worm, and the maggots from them enter the body of the worm and there absorb its juices and tissues, thus

soon killing it. Ordinarily, when feeding at night, the worms are free from these parasites, but when the marching habit is assumed these little flies swarm around them on cloudy days, and before the next year will again have the voracious army under subjection. Thus worms with eggs upon them should never be destroyed if avoidable.

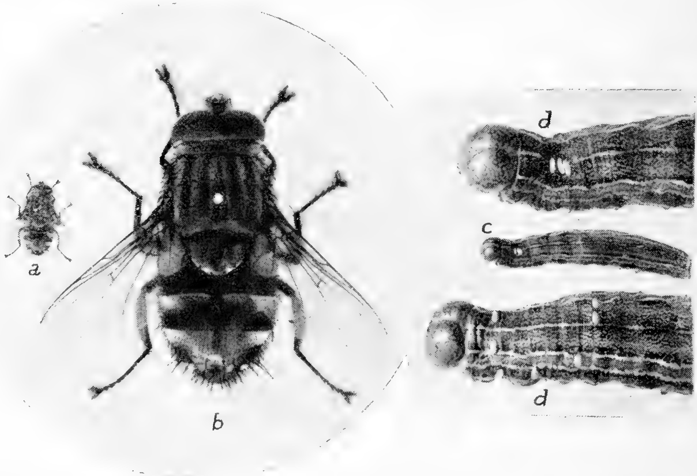

FIG. 52.—The Farmer's Friend, the Red-tailed Tachina fly (*Winthemia 4-pustulata*). *a*, natural size; *b*, much enlarged; *c*, armyworm on which fly has laid eggs, natural size; *d*, same, much enlarged. (After Slingerland.)

Remedies.—When detected, all efforts should be centred on keeping the worms out of crops not yet attacked and confining their injury to one point. As a barrier, there is nothing better than a steep ditch with the side next to the crop to be protected as nearly vertical as possible. In the bottom of this dig some deep holes every ten feet. Not being able to easily scale the steep wall, the worms will look for some easier ascent, and become accumulated in large numbers in the holes, where they may be destroyed

FIG. 51.—Army-worms at work on Corn-plant. (After Slingerland.)

by kerosene or by burning straw on them. Several deep parallel furrows will act in the same way, and if a series are properly made, they will also be found efficient. If it be possible to turn water in the ditches, or if they become filled by rains, the addition of a little kerosene, so as to form a thin scum over the surface, will soon kill the caterpillars.

By thoroughly spraying or, perhaps better, dusting a small strip of the crop in advance of the worms with Paris green, and liberally distributing poisoned bran mash (composed of fifty pounds of bran and one pound of Paris green with about enough molasses and water to sweeten it) large numbers may be destroyed. But be careful not to pasture cattle in a field so poisoned until rain has thoroughly washed it. A flock of poultry will also do good service in consuming them. Burning stubble, grass land, and rubbish is also of considerable importance for this as well as all similar insects. But whatever is done to combat the Army-worm must be done quickly and at once, for a single day's delay may often mean the ruin of a valuable crop. Deep fall plowing followed by a thorough harrowing or rolling will do much to destroy the hibernating larvæ and thus prevent their attack the next season.

The Fall Army-worm (*Laphygma frugiperda* S. & A.).

Description.—Very similar in its destructive habits to the true Army-worm is the Fall Army-worm or Grass-worm. At first glance the worms have much the same general appearance, bat upon close examination considerable difference in the markings is noticeable. Along each side of the body is a longitudinal pitch-colored stripe, and in the middle—between them—is a yellowish-gray stripe about twice as wide, which includes four black dots

arranged in pairs. These worms assume the habit of working in armies, but usually do not feed in such large bodies as those of the true Army-worm and are thus even more difficult to combat. They appear later in the season, the other species rarely being destructive after August first, and have thus been termed the Fall Army-worm. The Army-worm proper rarely feeds upon anything but grasses and cereals, while the Fall Army-worm feeds upon a large variety of cultivated crops, including sugar-beets, cow-peas, sweet-potato vines, millet, and many other general and truck crops. In Nebraska it has developed a peculiar fondness for alfalfa and has there been styled the Alfalfa-worm. It is also sometimes very destructive to city lawns, as it was in Chicago during 1899. Indeed, that season witnessed an unusual outbreak of this species in widely distant localities, it having been exceptionally destructive in the Carolinas and Virginia, Illinois, and Nebraska, as well as other districts. The insect is more of a native of the Southern States, but occurs from Canada and Maine south to the Gulf States and west to Colorado and Montana.

Life-history.—The life-history of this insect differs from that of the true Army-worm in that it passes the winter in the pupal stage. The pupæ are about one-half an inch long and may be found in small cells from one-half to one and one-quarter inches beneath the surface of the soil. The exact time of the emergence of the moths in the spring has not been definitely observed, but the first generation of worms appears in May or June. The moths deposit their eggs on blades of grass, in clusters of 50, 60, or more, each mass being covered with mouse-colored down from the body of the moth. The eggs hatch in

about ten days. The exact time required for the growth of the larva or the time occupied in the pupal stage does not seem to have been definitely observed. "Present knowledge indicates that the number of generations that are normally produced each year is two in the most northern range of the species (in years when it develops northward), three for central localities like central and southern Illinois and the District of Columbia, and probably four for the extreme South. We know, however,

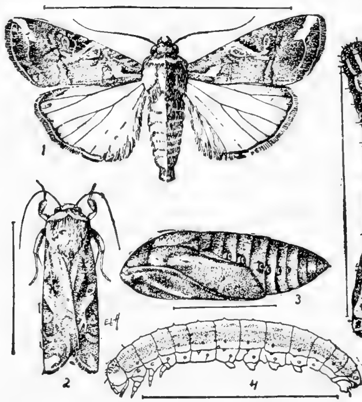

FIG. 53.—Fall Army-worm (*Laphygma frugiperda* S. & A.). 1, 2, moth; 3, pupa; 4, 5, larva. (After W. D. Hunter.)

practically nothing of the development of this species in the Gulf States." *

Prof. Morgan states that this insect often makes its appearance in damaging numbers in the States around the Mississippi Delta, in sections behind the levees immediately after an overflow or crevasse. This seems to be largely due to the predaceous ground-beetles (see page 36), which usually prey upon the army-worms in such numbers as to

* F. H. Chittenden, "The Fall Army-worm," Bulletin 29, n. s., Div. Ent., U. S. Dept. Agr.

hold them in check, being destroyed or carried to other places by the rush of water.

The parent moth is very dissimilar from that of the Army-worm. It is of a "general yellowish, ash-gray color, with the second pair of wings almost transparent, but with a purplish reflection. In extent of wings it measures about one and one-quarter inches, and when these are closed the length of the insect is about three-quarters of an inch. The front wings are mottled or marbled, especially near the central area, and usually there is visible a fine white line a short distance from the edge and parallel to it. The hind wings have a fringe of darker hair as well as veins that contrast somewhat with the lighter portion."*

Remedies.—As before stated, this species is even more difficult to combat than the true Army-worm on account of the fact that its attacks are scattered over a wider area, the individuals being of more solitary habits. The same methods of combating it will be found profitable, however, and especially that of deep fall plowing and harrowing, which in this case will break up the pupal cells and prevent the development of the moths. "In the case of perennial crops fall plowing is not practicable. For alfalfa Mr. Hunter has recommended that the field should be thoroughly 'disked,' or cultivated with a disk-harrow, giving practically the same results as plowing other fields. For lawns a thorough going over with a long-toothed steel rake is the treatment recommended."

"In fields of young grain and on lawns many of the worms may be killed by rolling with a heavy roller, preferably when the insects are at work early in the morning or

---

* Press Bulletin No. 2, Nebr. Ag. Exp. Sta., "The Fall Army Worm," W. D. Hunter.

late in the afternoon. In pasture-lands and in fields that are injured beyond recovery, sheep or cattle could be turned in in numbers with benefit, as they will crush the larvæ by trampling upon them."

The worms may often be destroyed, when not occurring in too large numbers and especially while young, by spraying the food with Paris green or other arsenicals, and when present in only ordinary numbers like cutworms they may be killed with poisoned bran mash as advised for the latter on page 217.

"Lawns can be freed from the insects by the application of kerosene emulsion, followed with as copious a drenching of water as possible from a hose. This remedy should not be employed in bright sunlight or on a hot day, but preferably toward sundown."

When the worms occur in armies they may be combated in the same way as the true Army-worm.

But too much emphasis cannot be placed upon the importance of *clean cultural methods and the rotation of crops* in the control of both this and the true Army-worm. This has been well expressed by Mr. Chittenden (l. c.) as follows: "Rotation of crops should always be practiced, as well as the burning over of fields in the fall, when they are too badly infested to recover from injury. Above all other precautions which it is necessary to take to secure immunity from attack is that of keeping the fields free from volunteer grain and wild grasses, since experience shows that these are the favorite breeding-grounds of the insect; in other words, they attract the female moths for the deposition of their eggs, and when the larvæ hatching from these eggs have devoured the grain and grasses which grow in batches they are driven to cultivated fields for

food. One of the most important sources of injury is the rotation of one cereal crop with another or with grasses, and the planting of crops in fields that have been allowed to run waste to wild grasses and weeds. As grasses and cereals are the crops most affected by the Fall Army-worm, the soil should always be very thoroughly plowed before planting to any crop, particularly a similar one, and it is inadvisable (not alone on account of the Fall Army-worm, but on account of the numerous other common cutworms, wireworms, and white grubs) to plant wheat, corn, or any other cereal in pasture-land unless a crop which is not so subject to infestation by this insect intervenes."

CHAPTER VI.

INSECTS INJURIOUS TO WHEAT.

INJURING THE ROOTS.

Meadow-maggots or Leather-jackets (*Tipulidæ*).

SEVERAL instances have been recorded in which serious injury has been done to wheat, clover, timothy, and blue grass by the larvæ of Crane-flies. These insects are never so injurious in this country as in Europe, where they are known as "Daddy-long-legs," the common name of our harvest-spiders, though doubtless injury done by them is often attributed to other insects. The farmer usually declares the work to be that of wireworms or cutworms, the adults often being known as "cutworm-flies," unless the maggots are so abundant as to attract his attention. When the maggots are abundant enough to do much injury, they usually occur in very large numbers, but ordinarily, though common everywhere, they occur in such small numbers as to escape notice.

Several species (*Tipula bicornis* Loew, *T. costalis* Say, and *Pachyrrhinis* sp.?) have at various times done considerable damage in localities in Ohio, Indiana, Illinois, and elsewhere.

Life-history.—So far as studied, the life-histories of these species seem to be much the same. The larvæ

remain dormant over winter, but evidently commence feeding again very early in the spring, a wheat-field having shown the effects of their injuries from February first to

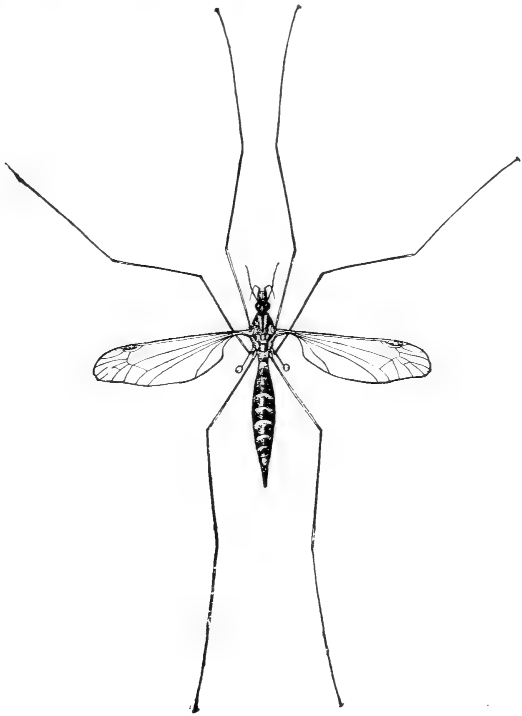

FIG. 54.—A Crane-fly (*Tipula hebes* Loew). *a*, larva; *b*, pupa; *c*, male adult. (After Weed.)

April first. The larvæ become full-grown from the latter part of April until the middle of May, depending upon the species and season. The full-grown maggots are about an inch long, of a dirty-grayish color, and of a tough

leathery texture. They are nearly cylindrical, somewhat tapering in front and terminating bluntly behind. Legs are entirely wanting, but at the blunt end are a few fleshy processes and a pair of small, horny hooks. The larvæ seem to prefer low, moist ground, and will live for some time on land entirely flooded or in a ditch. They feed very largely on dead vegetable matter, but when excessively abundant they attack the roots of wheat, grass, and clover, so weakening them near the surface that the plants, deprived of proper nourishment, are killed and loosened from the ground.

Pupæ may be found during the latter part of May, occupying small cells near the surface of the soil in a vertical position. Prior to emerging the adult pushes from one-half to two-thirds of the body above the surface and remains in this pose for several hours. The males usually emerge first, as their assistance is required by the females, which are loaded down with eggs, to extricate themselves from the pupal skins. The sexes pair immediately, there being many more males than females—one observer states one hundred to one—and the females deposit their eggs upon grass and clover lands, to the number of three hundred each. Eggs are laid for another brood in September, the maggots from which live over winter.

Remedies.—Injury to wheat land may be largely prevented by plowing early in September.

No satisfactory remedy for the maggots is known when injuring clover, timothy, or grass, although large numbers have been known to be destroyed by driving a flock of sheep over infested land. Dr. S. A. Forbes states that "close trampling of the earth by the slow passage of a

drove of pigs would doubtless answer the same purpose, which is that of destroying the larvæ lying free upon the surface or barely embedded among the roots of the grass."

Several of our common birds feed upon the maggots and flies as well as a number of ground-beetles. The maggots are also sometimes attacked by a fungous disease which in the damp soil in which they live would doubtless grow and spread rapidly. Altogether these different enemies keep them so well in check that they rarely become of importance.

Wheat Joint-worms (*Isosoma* spp.).

Injury.—During midsummer, shortly before harvest, many of the ripening ears of wheat are seen to topple over and fall to the ground, owing to the breaking of the stalk, which has been weakened at one of the joints. Upon examination several small gall-like cavities will be found fractured at the broken joint, and at other joints will be found small round holes leading to some of these empty cells. Now and then one will be found occupied by a small larva or pupa, the cause of all the mischief. Very often this injury becomes quite serious, affecting the crop much as does that of the Hessian Fly, though late in the season, and is often mistaken for the work of that species. The Joint-worms, however, are larvæ of small hymenopterous insects which were at first supposed to be parasitic upon the Hessian Fly, as they belong to a family, the *Chalcididæ*, most of the members of which are parasites of other insects. They differ from the flies in having four wings instead of two, and in many other structural points, as shown by the illustration, belonging to the same order as the bees, ants, and wasps.

Two species are commonly injurious, the Wheat Joint-worm (*Isosoma tritici* Fitch) and another species of the same genus, more popularly known as the Wheat Straw-worm (*Isosoma grande* Riley). The adults of *I. tritici* are small black flies from an eighth to three-sixteenths of an inch in length, and with wings expanding about one fourth of an inch. The larvæ are yellowish-white with the tips of the jaws brown, of about the same length as the fly, and of the form shown in the figure.

Life-history.—The larvæ of *I. grande* are much the same; but while the former species has but a single brood each season, this is double-brooded. The summer brood

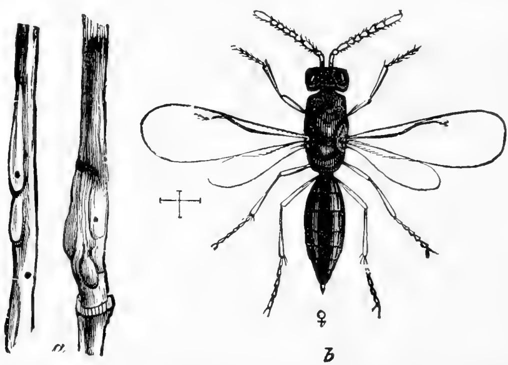

FIG. 55.—*a*, Wheat-straw affected by Joint-worm; *b*, adult as seen from above. (After Riley.)

is similar to that of *tritici*, but the spring brood is peculiar in that the females are much smaller and almost wingless, so that the pest is spread only by the later brood. The larvæ of *tritici* hibernate over winter in the wheat-stubble, coming to maturity in June, and the next brood feeds upon volunteer wheat and the fall planting. *I. grande*, however, passes the winter in the pupal state, also in the

stubble. From them the wingless females emerge in early spring and place their eggs upon the young wheat, usually on or near the growing head. These become mature in June, and from them the winged females develop. Singularly, there are no males in this brood, they appearing only in the spring, while in the summer brood the females are so large and robust that they were at first mistaken for a

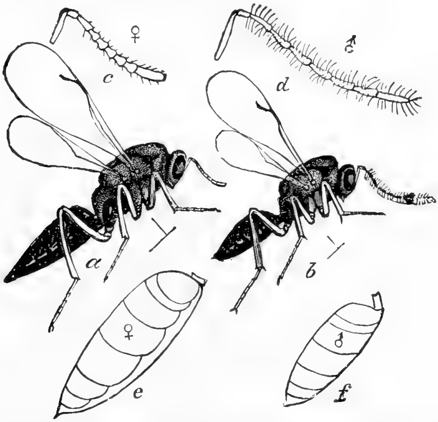

FIG. 56.—Adult of Joint-worm (*Isosoma tritici* Harr.). *a*, female; *b*, male; *c*, *d*, antennæ of same; *e*, *f*, abdomens of same. (After Riley.)

separate species. "These deposit their eggs in or near the joints of the straw, more frequently the second below the head," becoming full-grown by fall, and passing the winter in the stubble as pupæ. The two species may also be separated by their manner of injuring the straw. The Joint-worm (*tritici*) makes more or less apparent galls in the walls of the culm, while the Straw-worm (*grande*) forms no galls and but fewer individuals infest a straw.

Owing to their small size and retiring habits these little parasites of the wheat-plant—and they also infest barley

and rye—are not often observed, or their injuries are charged against the Hessian Fly, and not until they do

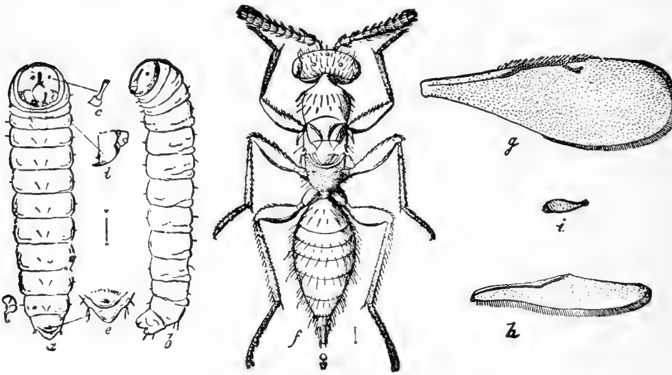

FIG. 57.—Wheat straw Worm (*Isosoma grande* Riley). *a*, ventral view; *b*, side view of larva; *c*, antennæ; *d*, mandible; *e*, anal segment, ventral view; *f*, adult female; *g*, forewing; *h*, hindwing; *i*, aborted wing. (After Riley.)

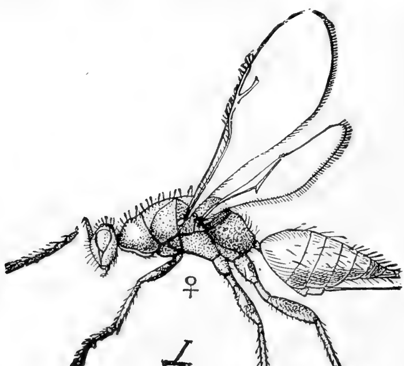

FIG. 58.—*Isosoma grande*. Female of summer brood. (After Riley.)

unusual and severe injury is the difference in the method of their attack from that of the "fly" noticed.

Remedies.—Owing to the fact that the Straw-worm is spread only by the summer brood, a simple rotation of the crop will keep them largely under control. However, as both species pass the winter in the stubble, most of them may be killed by burning the stubble in fall and winter.

The Wheat Saw-fly Borer (*Cephus pygmæus* Linn.).

The "Corn Saw-fly" has been a well-known wheat-pest for many years throughout England, France, and the Continent, but was not noted as injurious in this country till 1889, when Prof. J. H. Comstock published * a very complete account of its injuries upon the University Farm at Ithaca, N. Y., where it had done more or less damage for two years, though Mr. F. H. Chittenden states that he collected a single adult at Ithaca in the early '80's. Specimens were also collected at Ottawa, Canada, and Buffalo, N. Y., in 1887 and 1888, these being the only other references to its occurrence in this country.

The following is gleaned from Prof. Comstock's interesting account.

Injury.—No external indications of injury to the plant can be seen until the larva within has almost completely tunneled the stalk, at which time there is a discoloration just below the injured joints. Thus damage by this insect is not readily noticed, it merely dwarfing and stunting the growth of the plant by boring in the stem.

"If infested straws be examined a week or ten days before the ripening of the wheat, the cause of this injury can be found at work within them. It is at that time a yellowish, milky-white worm, varying in size from one-fifth

---

* Bulletin 11, Cornell Univ. Ag. Exp. Station.

to one-half an inch in length. The smaller ones may not have bored through a single joint; while the larger ones will have tunneled all of them, except, perhaps, the one next to the ground.

Life-history.—"As the grain becomes ripe the larva works its way toward the ground; and at the time of

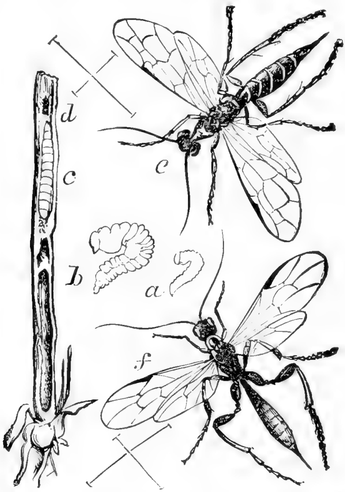

FIG. 59.—The Wheat Saw-fly Borer (*Cephus pygmæus* Linn.). *a*, outline of larva, natural size; *b*, larva, enlarged; *c*, larva in wheat-stalk, natural size; *d*, frass; *e*, adult female; *f*, *Pachyonerus calcitrator*, female, a parasite—enlarged. (After Curtis, from "Insect Life.")

harvest the greater number of them have penetrated the root. Here, in the lowest part of the cavity of the straw, they make preparations for passing the winter, and even for their escape from the straw the following year. This is done by cutting the straw circularly on the inside, nearly severing it a short distance, varying from one-half to one inch, from the ground. If the wheat were growing wild, the winter winds would cause the stalk to break at

FIG. 60.—The Wheat Saw-fly (*Cephus pygmæus*). *a*, female beginning to oviposit; *b*, female with ovipositor inserted in straw; *c*, insect with wings expanded; *d*, straws cut by larvæ; *e*, larva in cell at base of straw. (After Comstock.)

[*To face page* 98.]

this point; and thus the insect after it had reached the adult state could easily escape; while but for this cut it would be very liable to be imprisoned in the straw." Ordinarily, the straw is cut by the reaper before it becomes broken; but a strong wind just before harvest will cause a large number of stalks to become broken, much as if affected by the Hessian Fly.

"After the circular cut has been made, the larva fills the cavity of the straw just below it for a short distance with a plug of borings. Between this plug and the lower end of the cavity of the straw there is a place about one-half an inch in length. It is here that the insect passes the winter." This cell is lined with silk so as to form a warm cocoon. Here the larva passes the winter and changes to a pupa in March or April. The adult insect emerges early in May. The adults are four-winged insects, and are popularly known as Saw-flies on account of the saw-like ovipositor of the female, by means of which she inserts her eggs in the tissue of the plant. This species is quite different in some respects from the saw-flies feeding upon the leaves of wheat, and belongs to the family *Cephidæ*.

The female commences to lay eggs by the middle of May. By means of her sharp ovipositor she makes a very small slit any place in the stalk of the plant and in this thrusts a small white egg—about one one-hundredth of an inch long—which is pushed clear through the walls of the straw and left adhering to the inside. Though several eggs are deposited in a straw, but one larva usually develops. "The eggs hatch soon after they are laid, and the larvæ may develop quite rapidly. A larva which hatched from an egg laid May 13th was found to have

tunneled the entire length of the stalk in which it was" on May 28th.

Remedies.—"The most obvious method of combating the insect is to attack it while it is in the stubble; that is, some time between harvest and the following May. If the stubble can be burned in the autumn, the larvæ in it can be destroyed. The same thing could be accomplished by plowing the stubble under, which would prevent the escape of the adult flies. But as it is (often) customary . . . to sow grass-seed with wheat, it is feared that the plowing under of infested stubble would rarely be practicable; and it is also questionable if the burning of the stubble could be thoroughly done without destroying the young grass. It would seem probable, therefore, that if this insect becomes a very serious pest, it will be necessary . . . either to sow grass-seed with oats and burn or plow under all the wheat-stubble, or to suspend growing wheat for one year, in order to destroy the insects by starvation."

The Hessian Fly (*Cecidomyia destructor* Say).

Of the injurious insects peculiar to the wheat-plant the Hessian Fly is undoubtedly the most widely distributed and most destructive. Very often it is responsible for the loss of from one-fourth to one-half of the crop; and one-tenth of the whole yield, or from 55 to 65 million bushels, is estimated to represent the amount lost by its annual ravages. Excessive injury by this as by most other insects comes periodically. Thus "Hessian Fly years" have occurred in New York in 1779, 1817, 1844, 1845, 1846, and 1877, and in the three last years commencing with 1899. In 1846 it has been "estimated that the loss from the pest in western New York was not less than 500,000

bushels." Professors Roberts, Slingerland, and Stone (l. c.) state that the destruction during the past three seasons has been the most severe ever experienced in New York, conservatively estimating the loss in 1901 at 3,500,000 bushels of wheat, valued at about $3,000,000. Injury has also been wide-spread and severe in Ohio, Michigan, and neighboring States during the past few seasons, owing to peculiar climatic conditions. In 1900 Prof. F. M. Webster stated that a loss of about 60 per cent of the wheat crop in Ohio, amounting to 24,000,000 bushels and valued, at the market-rate, at $16,800,000, was due to injury by this pest.

History.—Having been first noticed as injurious on Long Island, in 1779, near where the Hessian troops had landed three years before, it seems altogether probable that it was brought to this country by them, and it has therefore been so named. Rapidly spreading over all the wheat land in the East, it appeared in California in 1884, was reported as injurious in England in 1886, and in 1888 was found to be destructive in New Zealand.

Description and Life-history.—The adult flies are little, dark-colored gnats, about one-eighth of an inch long, but these are less often seen than the immature stages. Each of the females lays from one hundred to one hundred and fifty minute reddish eggs, placing them in irregular rows of from three to five, generally upon the upper surface of the leaf, but in the spring often beneath the sheath of the leaf. In a few days these hatch into small, reddish maggots, which soon turn white, are cylindrical, about twice as long as broad, and have no true head or legs. The fall brood of maggots burrow beneath the sheath of the leaf and its base, which is still below the

ground, causing a slight enlargement at the point of attack; but in the spring they usually stop at one of the lower joints above the surface, in both instances becoming fixed in the plant and weakening it by absorbing its sap and tissues.

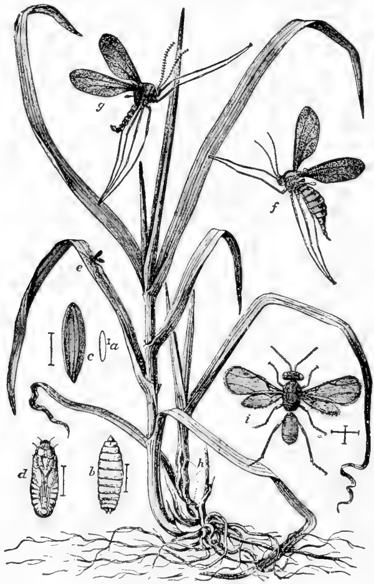

FIG. 61.—The Hessian Fly and its various stages of development. *a*, an egg; *b*, larva or worm; *c*, flaxseed; *d*, pupa; *e*, adult, laying eggs; *f*, female; *g*, male; *h*, stalk of wheat showing attack; *i*, natural enemy or parasite—all enlarged except wheat-stem and fig. *e*. (After Riley, Burgess, and Trouvelot, from U. S. Dept. Agr.).

This difference in method of attack results in a corresponding effect on the plant. The first indication of the work of the maggots in the fall is the tendency of the plants to stool out; the dark color of the leaves, which are somewhat broader, and the absence of the central stems

also reveal their presence. Later, many of the plants may be observed to turn yellow and die. The spring maggots attack the laterals, or tillers, which have escaped the previous brood, so weakening them that the stems break and fall before ripening, and cannot be readily harvested.

In about four weeks the maggots become full-grown, and are then light greenish white and about three-sixteenths of an inch long. The skin now turns brown, shrivels slightly, and inside of it is formed the new stage, called the pupa. This outside case, composed of the cast larval skin, is known as the puparium, and this stage is generally called the "flax-seed" stage from the close resemblance to that seed. In this stage the fall brood passes the winter, the flies emerging in April or May, while the spring brood so remains during midsummer, and emerges during September. Besides the above, there are often two supplemental broods, one following the spring brood, and the other preceding that of the fall.

Enemies.—Several parasites are of great value in holding the numbers of the fly in check, but as yet no method is known whereby they may be artificially encouraged. Attempts to import foreign parasites have not, as yet, been permanently successful. It is owing to these parasites being destroyed by unfavorable weather conditions that the fly becomes excessively abundant.

Preventives.—Owing to the wide distribution of this pest, and the corresponding variation of latitude and altitude, it is evident that the time of its appearance will vary considerably, and any preventive measures must be based upon a previous determination of the time of appearance of the broods for any given locality. Recently it has been shown that weather conditions largely determine the time of

appearance of the fall brood, a season of drought in early September retarding the emergence of the flies until rain falls. Professors Roberts and Slingerland state that "a

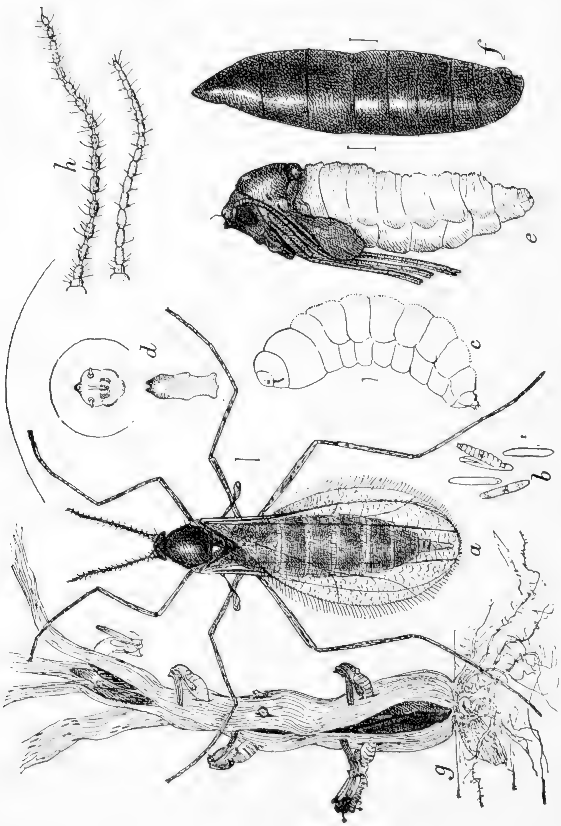

FIG. 62.—The Hessian Fly (*Cecidomyia destructor*). *a*, female fly; *b*, flaxseed stage or pupa; *c*, larva; *d*, head and breast-bone of same; *e*, puparium; *f*, cocoon; *g*, infested wheat-stem showing emergence of pupæ and adults. (After Marlatt, Farmers' Bulletin, 132, U. S. Dept. Agr.).

mild October and November often emphasizes the fly's destructiveness. A damp spring, even though a cold one, is also favorable to the development of the insect. On the contrary, dry hot summers are unfavorable, and often

cause a serious mortality to the earlier stages of the fall brood of adults; and a rainless August often retards the emergence of the flies until even our latest-sown wheat (in New York) is up and ready to receive their eggs. Just such weather conditions occurred in New York in 1900 and, we believe, were largely responsible for the fact that in many cases late-sown fields were as badly infested as those sown earlier." If there be a normal rainfall in August, the flies will emerge as usual early in September and will lay their eggs on volunteer, early-sown, and trap strips of wheat, and late sowings will largely escape.

Dr. A. D. Hopkins has recently worked out a most valuable law governing the time of appearance of this pest, and from which he has deduced a rule for "the approximate determination of normal dates for the ending of the fall swarm of the Hessian Fly in any locality" in West Virginia. "Take a known normal date of a place, of known latitude and altitude, correct this date to a corresponding date at sea-level, by adding one day to each one hundred feet of altitude above sea-level; then for any place north of this sea-level base subtract one day for each one-fourth degree of latitude and one day for each one hundred feet of altitude at the place to be determined, and for all points south add one day for each one-fourth degree of latitude and subtract from the result, as before, one day for each one hundred feet of altitude. The resulting date will be the approximate normal.

"To give an example of this method of determining normals, and to demonstrate its value, we will take, as the most important and reliable data, the results obtained by Prof. Webster, by actual experiments and observations, at Columbus and Wooster, Ohio. He found that the normal

date for the ending of the fall period of active flight or swarming of the fly at Columbus, latitude 40 degrees, was September 25th, and that the corresponding date for Wooster, latitude 40 degrees and 49 minutes, was September 20th, which he states agrees almost exactly with results obtained in Indiana, and forms the base of conclusions, as set forth in his Bulletin No. 107." Columbus is 800 and Wooster 1000 feet above sea-level. By applying the above rule and computing the date of Wooster from that of Columbus, or *vice versa*, the same dates will be secured as those determined by Prof. Webster.

Of the various farm methods of control the most important is the late planting of winter wheat through the Central States. In the latitude and altitude of northern Ohio if this be done after September 12th the flies will all have laid their eggs before the plants sprout. The time of planting should be later the further south, but no arbitrary dates can be given for the whole country, as those must be determined by altitude, latitude, and local conditions. Thus in extreme southern Ohio October 10th is stated to be a safe time, while in central Maryland, in the same latitude, wheat may commence to be sown between September 25th and October 5th. In northern Delaware farmers prefer not to sow until October 1st. Prof. Roberts states that though no definite dates can be given owing to injury being most serious after abnormal weather conditions, after which the dates would be different, yet that "New York wheat-growers have learned that wheat sown after the 20th to the 25th of September is usually much less infested. In Ohio and Michigan, as elsewhere, it has been found that wheat sown very early, i.e , about September 1st, and late, i.e., after October 1st, is but slightly

injured, while that planted during the middle of September is largely or wholly destroyed.

Fig. 63 shows the proper dates for planting in Ohio as given by Prof. Webster. Various State experiment stations have issued bulletins giving the proper time to plant in those States, and should the rule given by Dr. Hopkins prove to be applicable throughout the country, the problem of when to plant will be easily solved.*

Inasmuch as most of the spring brood remain in the stubble in the flaxseed stage after harvest, if the fields be then burned over, large numbers will be destroyed, but often this is impossible owing to the practice of seeding wheat land to grass and clover, which is quite a common practice in many sections. By the destruction of all volunteer wheat the two supplementary broods may be reduced, and in the extreme North, where this is the principal means of carrying the insect over winter and spring wheat is grown, this will be found of considerable importance.

By planting a few strips of wheat late in August or in the first week of September many of the flies will be decoyed into laying their eggs upon them, and by then plowing under these strips the eggs and larvæ may be destroyed and the regular sowing thus protected. The trap strips should not be allowed to stand over about

---

* See W. Va. Agr. Exp. Station, Bulletin No. 67: The Hessian Fly in W. Va., A. D. Hopkins. Ohio Agr. Exp. Sta., Bulletins Nos. 107, 119: F. M. Webster. Md. Agr. Exp. Sta., Bulletin No. 58: W. G. Johnson. U. S. Dept. Agr., Div. Ent., n. s.: The Hessian Fly in the United States, Herbert Osborn. Cornell University Agr. Exp. Sta., Bulletin 194: The Hessian Fly, I. P. Roberts, M. V. Slingerland, and J. L. Stone.

FIG. 63.—Map indicating, in bold faced type, the approximate dates immediately after which it is usually safe to sow wheat in the fall, in various sections of Ohio, in order to avoid the autumn attack of Hessian fly. Dates given in small type show when wheat sown in the fall of 1899 escaped the fall attack, though it was in many cases totally destroyed by the spring attack. The difference between these dates is the variation from the normal, and where no dates are given between the cross-lines there was no such variation. (After Webster.)

four weeks, or three or four days after the main crop is sown.

Though none are exempt from attack, those varieties of wheat "with large, coarse, strong straw are less liable to injury than weak-strawed and slow-growing varieties." In New York in many localities in 1901 a wheat called Dawson's Golden Chaff was found to be but little injured, where others were nearly destroyed. However, in Canada, where this variety originated, it is as seriously injured as other kinds, and may become so in New York. Bearded Red Wheat No. 8 was also found to be a very resistant variety, as were Prosperity, Democrat, Red Rusisan, and White Chaff Mediterranean. It should be remembered, however, that none of these are invariably "fly-proof," and that though under certain conditions they may be but little injured, in other localities and under less favorable circumstances they may be injured as much as any other sorts.

Among other conclusions Prof. Roberts and his colleagues state that the fly "injures wheat more on dryish and poor land than on moist but well-drained, rich soils." Also, "that the soil must be so well fitted and so fertile that a strong, healthy growth will be secured in the fall, though the sowing of the seed be delayed ten to fifteen days beyond the usual time. Such preparation of the soil will also help the wheat to recover from any winter injury. Thick seeding and vigorous growth also tend to ward off the fly." "Much stress should be laid on the proper fitting of the land for wheat. Plowing should be done early—at least six weeks before sowing—to give abundant time for the repeated working of the soil in order to recompact the subsurface soil and secure a fine but

shallow seed-bed in which there has been developed, by tillage and the action of the atmosphere, an abundance of readily available plant-food. Manures and fertilizers should be kept near the surface and the young roots encouraged to spread out on the surface soil, thus avoiding much of the damage by heaving in winter and leaving the deeper soil for fresh pasturage for the plants during the following spring and summer."

Prof. Webster strongly recommends the rotation of the wheat-crop, sowing it as far from where it was grown the previous year as possible. Where this has been judiciously done, individual farms have often remained free from serious attack when neighboring ones were badly injured.

Remedies.—After injury by the fly has once become apparent in the fall, there is no application known by which it may be destroyed. The application of a liberal amount of fertilizer to land not already well fertilized will enable the plants to better withstand the injury and possibly outgrow it. Pasturing sheep on early-sown fields would doubtless result in crushing many of the flaxseeds and larvæ, and give the ground that compact, pulverized nature which it should have.

Nothing is known as a remedy for injury by the spring brood.

In summarizing his knowledge of means of controlling this pest, Prof. F. M. Webster, who is probably our best authority upon it, says: "After thirteen [now fifteen] years of study of the Hessian Fly, I am satisfied that *four-fifths of its injuries may be prevented by a better system of agriculture.* For years I have seen wheat grown on one side of a division-fence without the loss of a bushel by attack of this pest, while on the other side the crop was invariably

always more or less injured. No effect of climate, meteorological conditions, or natural enemies could have brought about such a contrast of results. The whole secret was in the management of the soil and the seeding."

Some Wheat-maggots.

Very similar in its mode of injuring the wheat-stalk to the Hessian Fly is the Wheat Stem-maggot (*Meromyza americana* Fitch). The adult flies were first described by Dr. Fitch in 1856, though the work of the maggots had probably been noticed as early as 1821 by James Worth of Bucks County, Pa., and by the *Michigan Farmer* in Michigan about 1845.

Extending from Dakota and Manitoba to Texas, the range of this insect practically covers all the eastern United States and southern Canada.

Unlike the Hessian Fly it feeds and breeds upon wild grasses and is thus much more difficult to control. Prof. A. J. Cook found the larvæ in both barley and oats in Michigan, Prof. Webster reared an adult from Blue Grass (*Poa pratensis*), and Dr. Jas. Fletcher records it as breeding in *Agropyrum*, *Deschampsis*, *Elynius*, *Poa*, and *Setaria viridis* in Canada.

Life-history.—Like the Hessian Fly the adult flies lay their eggs on fall wheat in September and October, and the young maggots when hatched work their way down into the stem, either cutting it off or causing it to discolor or die. The eggs are about one-fortieth of an inch long and of a glistening white color. The larvæ are a light greenish color, about one-fourth of an inch long, tapering towards the terminal end while subcylindrical posteriorly, being quite elongate. The pupæ are the same color as the

larvæ, but more rounded, being only one-sixth of an inch long, and reveal the legs and wing-cases of the imago forming within them. The external case of the pupa, called the puparium, is merely the shrunken and hardened cast skin of the last larval stage, within which the insect

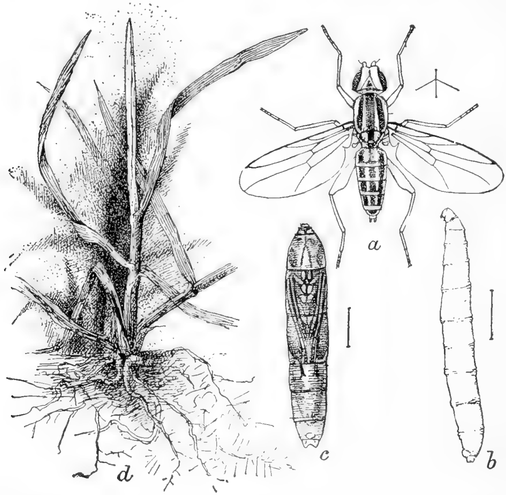

FIG. 64.—Wheat Bulb-worm (*Meromyza americana*) *a*, mature fly; *b*, larva; *c*, puparium; *d*, infested wheat-stem—all enlarged except *d*. (After Marlatt, U. S. Dept. Agr.)

transforms to the pupa. The fly is about one-fifth of an inch long. It is of a yellowish-white color with a black spot on the top of the head, three broad black stripes on the thorax, and three on the abdomen, which are often interrupted at the sutures, so that they form distinct spots. The eyes are a bright green.

The winter is passed by the larvæ in the young plants, and in spring they transform to pupæ and adult flies. These in turn deposit eggs in such a position that the maggots issuing from them may readily feed upon the

succulent portions of the growing stalk. Numerous larvæ thus sapping the life of the plant soon kill it outright or cause the top and head to wither and die. The adults of this brood emerge in July and lay eggs on volunteer wheat and grasses, the maggots working in the same manner as in the fall and coming to maturity so that another brood of flies lay eggs for the fall brood on the newly planted wheat.

Owing to the fact that this insect breeds also in grasses during late summer it is much more difficult to combat than were it confined to wheat as its food-plant, as is the Hessian Fly.

Remedies.—"If the grain is stacked or threshed and the straw stacked or burned," says Prof. Webster, "it is clear that the number escaping would be greatly reduced," for, as the adults emerge soon after harvest, they would escape to deposit their eggs were the straw left in the fields, but "it is not likely that those in the centre of the stacks would be able to make their way out, and the threshing-machine would destroy many more. How much could be accomplished by late sowing of grain is uncertain, as the females are known to occur abundantly up to October. If plots of grain were sowed immediately after harvest in the vicinity of the stacks, many of the females could, no doubt, be induced to deposit their eggs therein, and these could be destroyed by plowing under." Burning of the stubble will also aid in keeping this pest under control.

There are several undetermined species of flies belonging to the genus *Oscinis*, and very closely resembling the common house-fly in miniature, being about one-fourth as large, which have practically the same life-history as the Wheat Stem-maggot and injure the wheat in the same

manner. They will not need consideration by the practical farmer other than in applying methods of control as already given. One species of this genus, determined by Prof. H. Garman as *Oscinis variabilis* Loew and christened the American Frit-fly, has been found common in Kentucky and Canada, but is so nearly identical in

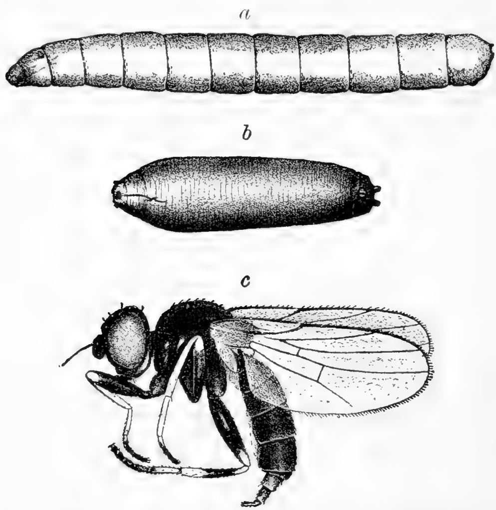

FIG. 65.—The American Frit-fly (*Oscinis variabilis* Loew). *a*, larva or maggot; *b*, puparium; *c*, adult fly. (After Garman.)

appearance and habit in the larval stage that it can with difficulty be distinguished from the Stem-maggot.

That these pests do not do more injury is probably due to a considerable extent to the fact that large numbers of them are destroyed by a small hymenopterous parasite, known as *Cœlinus meromyzæ* Forbes, which very commonly infests the larvæ, and by other parasites and predaceous insects.

Rarely will these pests do serious damage, but very often

it is sufficient to merit consideration, and only a knowledge of their life-history can give a key to their successful control.

INJURING THE LEAVES AND HEAD.

The Wheat-louse (*Nectarophora avenæ* Fab.).

History and Distribution.—At comparatively long intervals the wheat crop is extensively injured by the Wheat-louse or Grain-aphis. In 1861 and 1862 serious damage was done throughout New York and New England, which seems to have been the first serious outbreak of the pest in this country, it being a native of England. Since then the crop of 1889 throughout Kentucky, Ohio, Indiana, Illinois, Wisconsin, and Michigan was the worst damaged, sometimes to the extent of 60 per cent. The following year the lice appeared on the eastern shore of Maryland in large numbers, causing a total failure of the crop in some sections, and in 1894 they did serious damage in Washington and northern Idaho, where they had been known for some years. Though no record of its distribution is to be found, it would seem probable from the above that the Wheat-louse occurs throughout the northern half of the United States, as no mention of its occurrence in the South is found.

Like many aphids it rarely becomes excessively injurious, being usually held in check by internal parasites, predaceous insects, diseases, and weather conditions. Just how far the weather is directly responsible for their increase or decrease is unknown; but it has been observed that an outbreak is usually preceded by several dry seasons, and that cold, damp weather during late spring and early summer seems to favor their development. Parasitic

fungous diseases—mostly of the genus *Empusa*—are one of the most important checks to the multiplication of plant-lice, and, as they require wet weather for their best

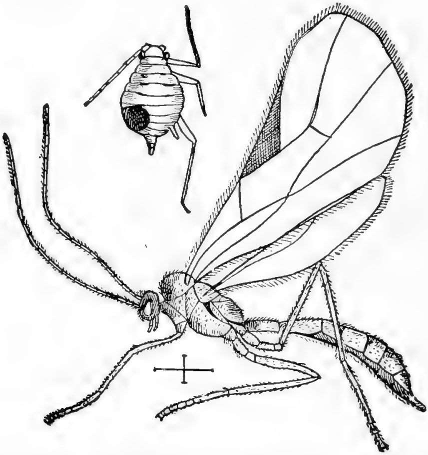

FIG. 66.—Wheat-louse Parasite (*Aphidius granariaphis* Cook), and parasitized louse from which it has issued. (Copied from J. B. Smith.)

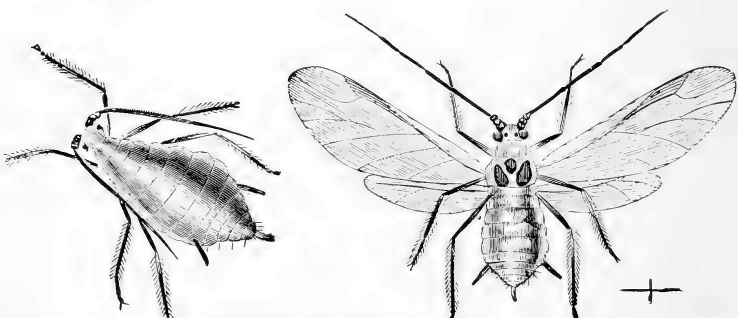

FIG. 67.—The Wheat-louse (*Nectarophora avenæ* Fab.). Wingless and winged forms. (After Garman.)

development, it is not surprising that several dry seasons should precede an abundance of lice. Prof. F. M. Webster

thinks that cold, wet weather in May and June is favorable to the lice, in that it retards the development of their parasites.

Description and Life-history.—The first individuals are found on the young wheat in the latter part of April, though during open winters they may remain on the young wheat, as observed by Dr. Cyrus Thomas in 1875 and Prof. H. Garman in 1889. Until early July the lice feed upon the wheat, first upon the stalk and leaves and later upon the head, breeding in the parthenogenetic manner of most aphids. (See life-history of Corn Root-aphis, page 136.) The color of the lice varies greatly, as does also the size. In the spring the winged lice are green, with head, antennæ, thorax, femora, tarsi, cornicles, and a series of spots on the sides of the abdomen black. As the grain matures and the lice migrate to the head, many of them become yellow, reddish, and some of the winged forms almost black. The wingless lice are of a pale green.

Oats, barley, rye, corn, blue grass, and many other grasses furnish food for this pest, and after the wheat becomes mature it may commonly be found on volunteer oats until the fall wheat appears. During the hot weather of midsummer, however, it is not much in evidence.

The true sexes occur in the fall, and eggs are laid upon the fall wheat.

Enemies.—Were it not for its parasites and the predaceous insects which feed upon it, the Wheat-aphis would indeed be a most serious past, but ordinarily these keep it well under control, and when for some reason they are themselves killed off for a season and the lice have opportunity to multiply, they soon become so numerous as to again

destroy so many as to prevent serious injury. The effect of these parasites and predaceous insects is indeed marvellous and is always a matter of observation to the farmer, who wonders if they are to finish the work of the lice and utterly destroy the crop. Prof. Webster says of them: "The effect of the parasites upon the grain-louse was simply astonishing, while their numbers were myriad. Going to the fields of recently harvested grain, if one stood in a position to bring the newly made shocks between himself and the setting sun, he could clearly observe the swarms of minute hymenoptera arising therefrom and flying away. Besides, the stubble-fields were overrun with lady-beetles and their larvæ." Several internal parasites belonging to the family *Braconidæ* (see page 41) are concerned in this good work, one variety, described by Prof. A. J. Cook as *Aphidius granariaphis* (Fig. 66), having been especially numerous in Michigan in 1889. All the common ladybird-beetles feed upon these lice, and with an abundance of food increase in numbers very rapidly. Several species of syrphus-flies and *Chrysopa* are equally fond of them, and are very numerous in infested fields.

Remedies.—As far as known no artificial remedy for the Wheat-louse has yet been found. Though the lice might be destroyed with various sprays, this is hardly practicable in a wheat-field; and inasmuch as the lice breed upon so many species of the grass family, there seems to be no cultural method for combating them. Ordinarily, therefore, we will have to trust to the good woebnrk of the eficial insects and diseases to prevent their depredations.

Wheat Saw-flies (*Dolerus* spp.).

Several species of saw-fly larvæ sometimes feed upon the leaves and rarely the heads of wheat, but seldom do serious injury. *Dolerus arvensis* Say and *Dolerus collaris* Say have both been reared upon wheat from Ohio and New Jersey, though both species occur throughout the United States and southern Canada east of the Rockies. The adult flies "are comparatively large, robust insects, of a dull black or bluish color, varied with yellow or reddish." "The larvæ are quite uniform in color and general characteristics. They have twenty-two legs, are cylindrical, and generally of a uniform grayish or slaty color, dorsally and laterally, but nearly white ventrally." *

The adults deposit their eggs in the spring, and larvæ are to be found early in June. The only record found of the life-history is that of *D. collaris* by Prof. Webster, who found that a larva collected on June 15, 1897, entered the ground in about ten days, and the first adult emerged January 11, 1898, though the adults usually appear later.

The most common saw-fly feeding upon wheat-foliage is *Pachynematus extensicornis* Norton. "The adult insects appear during the latter part of April and first of May, the males antedating the females several days. The eggs, when first laid, are of a light green color. They are inserted to the number of two to five, or more, together along the edges of the wheat-blades and just beneath the epidermis. Some fifteen or sixteen days elapse before hatching. The newly hatched larva is rather slender and

---

* Wheat and Grass Saw-flies. C. V. Riley and C. L. Marlatt, "Insect Life," Vol. IV, p. 169.

elongate, tapering gradually from the head to the last segment; head yellowish, eyes black. Full growth is attained in about five weeks, the mature larva having a length of about four-fifths of an inch. The head is of a pale clay-yellow color, the eyes are black, and the color of the body is green or yellowish green. The larva is at

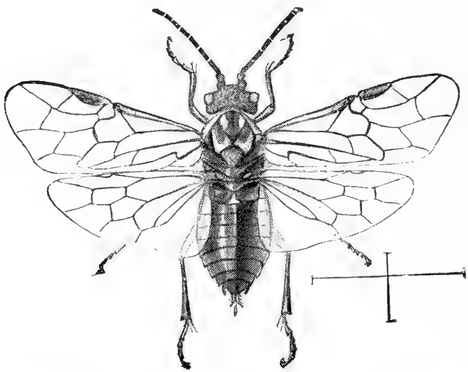

FIG. 68.—*Dolerus arvensis* Say, female. (After Riley and Marlatt, "Insect Life," U. S. Dept. Agr.)

once separated from the *Dolerus* larvæ by the possession of but seven pairs of abdominal feet." (R. & M., l. c.) When full-grown the larvæ enter the earth and construct silken cocoons, in which they doubtless remain unchanged over winter, transforming to pupæ shortly before the adults emerge the next spring. The form of the adults is well shown in the illustration. "The female is stout and in general light yellowish or ochraceous in color. The abdomen is for the most part dark brown or black, dorsally, except the posterior lateral margin and the extreme tip. The male is much more slender and elongate than the female, and is almost black in color, the tip

of the abdomen being reddish and part of the legs whitish." This species has been taken on wheat in Illinois, Nebraska, Delaware, Maryland, Ohio, Indiana, and Pennsylvania. During 1886 and 1887 it did considerable damage by cutting off the heads,—sometimes, as

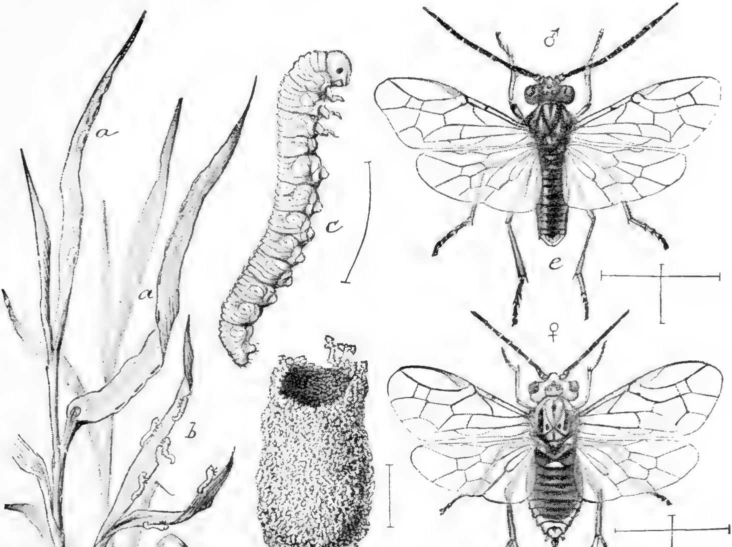

FIG. 69.—The Grass Saw-fly (*Pachynematus extensicornis* Norton). *a*, *a*, eggs on wheat-blade; *b*, young larvæ; *c*, full-grown larva; *d*, cocoon from which adult has emerged; *e*, *f*, adult insects—*e*, male; *f*, female. *a* and *b*, natural size; *c-f*, enlarged. (After Riley and Marlatt, U. S. Dept. Agr.)

stated by a Maryland man, cutting fully one-half of them. No more recent damage has been recorded, and owing to the slight damage usually done no remedies have received a practical test. Deep fall plowing might be of advantage by burying the larvæ so deeply that the adults would be unable to escape.

INJURING THE HEAD.

The Wheat-midge (*Diplosis tritici* Kirby).

History.—While the Hessian Fly attacks the stalk of the wheat-plant, another species of the same genus, known as the Wheat-midge, or "Red Weevil," often does very serious damage to the maturing head. It, too, is a foreigner, having first been noticed as injurious in Suffolk, England, in 1795, though probable references to its depredations date back as early as 1741. "In 'Ellis's Modern Husbandman' for 1745 the attacks of the vast numbers of black flies (the ichneumon parasites) are noticed in the following quaint terms: 'After this we have a melancholy sight, for, as soon as the wheat had done blooming, vast numbers of black flies attacked the wheat-ears and blowed a little yellow maggot which ate up some of the kernels in other parts of them, and which caused multitudes of ears to miss of their fulness, acting in some measure like a sort of locust, till rain fell and washed them off; and though this evil has happened in other summers to the wheat in some degree, yet if the good providence of God had not hindered it they might have ruined all the crops of wheat in the nation.' (Hind's 'Essay on Insects and Diseases Injurious to Wheat Crops,' page 76.)" * It seems probable that it was first introduced into America near Quebec, where it "appears to have occurred" in 1819, and was first observed in the United States in northwestern Vermont in 1820. It did not become very destructive, however, until 1828, from which time until 1835 it kept increasing in such numbers as to cause the

* The Wheat-midge. Bulletin No. 5, Vol. 1, 2d Ser., Ohio Ag. Exp. Sta., F. M. Webster.

abandonment of the wheat crops in some localities throughout northern New England. Serious damage was reported as due to this pest every few years until about 1860, being most severe in 1854,—in which year Dr. Fitch estimated the loss in New York alone at $15,000,000,—1857, and

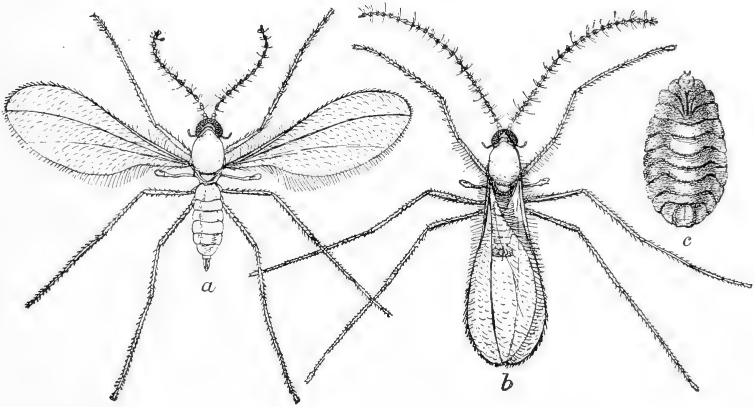

FIG. 70.—Wheat-midge (*Diplosis tritici*). *a*, female fly; *b*, male fly; *c*, larva from below. (After Marlatt, U. S. Dept. Agr.)

1858. Since then no wide-spread injury has occurred, though local outbreaks are frequent, and it has spread south to the Gulf States and westward to Iowa, Minnesota, and Arkansas.

Life-history.—The adult flies are small, two-winged insects, about an eighth of an inch long, of a yellow or orange color. They appear about the middle of June and lay the eggs "in a small cavity at the summit of, and formed by a groove in, the outmost chaff covering the incipient kernel." They hatch in about a week, according to Dr. Fitch, and the maggots burrow into the forming kernels. The maggots are of a reddish color, and when

an ear is badly infested give it a reddish tinge, on account of which the insect is often called the "Red Weevil."

When full-grown the larvæ enter the ground and usually form cocoons, in which they pass the winter in the pupal stage, though they often hibernate without such protection. Though doubtless there is usually but one brood in a season, observations by Prof. F. M. Webster and others seem to point to the fact that there sometimes are two broods, as adults have been observed from August into November.

Besides wheat, the wheat-midge also sometimes injures rye, barley, and oats.

Remedies.—Plowing infested fields in the fall so deeply that the midges will be unable to reach the surface upon developing in the spring is by far the best means of controlling this pest; while burning the stubble previous to plowing, and a rotation of the crop, will also be of considerable aid.*

---

* See "The Principal Insect Enemies of Growing Wheat," C. L. Marlatt, Farmers' Bulletin, No. 132, U. S. Dept. Agr.

CHAPTER VII.

INSECTS INJURIOUS TO CORN

INJURING THE ROOTS.

Corn Root-worms.

The Western Corn Root-worm (*Diabrotica longicornis* Say).

THE farmers and entomologists of the Central States have long known this as one of the worst pests with which they have to deal, and its progress eastward through Ohio has been a matter of considerable interest.

History. — Outside of entomological collections, the beetle was hardly known until 1878, when it first appeared in Illinois in such numbers as to cause any wide-spread damage. First observed by Say in 1823, who gave its habitat as Arkansas Territory, it was not again noticed until found numerous upon sorghum by Prof. W. S. Robinson of Kansas in 1866, who gave a large thistle as its native food-plant. In 1874 Prof. C. V. Riley received a larva from Kirkland, Mo., which had been found burrowing into the roots of corn with considerable injury, and again in 1878 from Eureka, Mo. Prof. Webster states that in Illinois from the spring of 1874 he collected only two specimens until the fall of 1877, when quite a number were taken in corn-fields. A rapid increase in numbers occurred during the next three years, and by 1880 its

injuries to corn in Illinois were so severe as to demand investigation. At that time it was stated by several farmers that the larvæ had been noted feeding on corn-

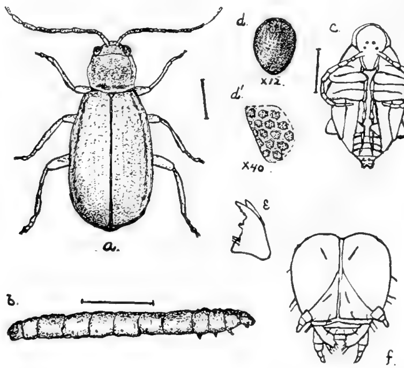

FIG. 71.—*Diabrotica longicornis* Say. *a*, beetle; *b*, larva—Western corn root-worm; *c*, pupa; *d*, egg; *d'*, portion of egg enlarged (×40); *e*, mandible of larva; *f*, head of larva from above. Hair-lines at sides natural size. (Redrawn from Forbes.)

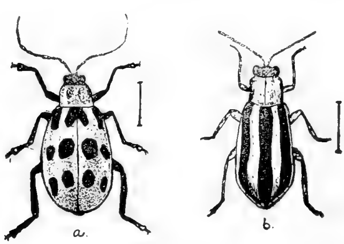

FIG. 72.—*a*, *Diabrotica 12-punctata* Oliv. Beetle of Southern corn root-worm; *b*, *Diabrotica vittata* Fab. Striped Cucumber-beetle. (Redrawn from Forbes.)

roots for ten or twelve years, and that serious damage had been done for at least seven years. Thus it is evident that in all probability the injuries to corn commenced in Missouri and Kansas during the early '70's, and, as soon

as the larvæ had acquired a decided taste for corn, spread gradually eastward into Illinois, where that is the staple crop.

In the spring of 1882 Professors Forbes and Webster began a careful study of the life-history, habits, and injuries of the insect, and to them we owe almost all our knowledge of it. At that time its injuries were found to be general throughout western Illinois, north of Centralia, and also in southeastern Iowa, destroying from five to *over fifty per cent* of the crop. In 1885 Prof. Webster found it abundant at Lafayette, Indiana, where the owner of one large estate estimated his loss at fifteen per cent of the whole crop, or a cash loss of $60,000.

Unnoticed in Ohio till 1892, in that year it was reported from Hamilton County, in the extreme southwestern corner of the State, and was also found in Van Wert County, in the northwestern part. Since then it has steadily advanced, each year spreading over one and one-half counties to the eastward, until in 1895 it had been reported from over almost the entire western half of the State. No special notice has been seen of any spread. While thus spreading eastward, it has become generally recognized in Kansas, Nebraska, Iowa, northern Missouri, Illinois, and Indiana.

Though never known to have been seriously injurious east of Ohio, the writer found ears of corn in a field near Ithaca, N. Y., which had been planted in that crop for several years, attacked by large numbers of the beetles. On September 15, 1897, the corn was fairly alive with the beetles, as many as a dozen being found eating the silk of a single ear, generally well under the husk. Mr. Harring-

ton has found the beetles on thistles as far east as New Brunswick. The only previous records of it in New York are those of Prof. Webster, who quotes Mr. Fred. Blanchard of Lowell, Mass., as having specimens from New York, and Mr. Ottomar Reinecke of Buffalo, who wrote that he had collected it there on willow prior to 1880. Though these statements are doubtless correct, there certainly is no record of it during the last fifteen years, and never of its having been injurious.

Life-history.—The life-history of the pest, though not completely known, is yet comparatively simple. The eggs are laid in the early fall, within a few inches of the base of the stalk, from one to five inches deep in the soil. The larvæ hatch from June to August, and at first eat the small roots entire, and then commence burrowing under the outer layers of the larger roots, causing the stalks to be easily blown over if on a rich loam, or small ears and a general dwarfing of the plant, if on poorer land. The adult worm is nearly white, with brown head, a little less than half an inch long by less than one-tenth of an inch in diameter. Three pairs of short legs are found on the segments immediately back of the head, but otherwise the long, cylindrical body appears perfectly smooth to the unaided eye, though seen to have numerous hairs and bristles under the microscope. Before pupation the color becomes slightly darker and the body shortens, becoming more like a common grub. They then leave the roots, form a small oval cell in the soil, transform to pupæ, and in a short time come forth as adult beetles.

The beetles are of a greenish or greenish-yellow color and about one-fourth of an inch long, resembling in form

the common Striped Cucumber-beetle. The adults are found in the fields from the latter part of July until the corn-silk becomes brown and dry, and often later, feeding upon the silk and pollen, thus doing more or less damage, though slight when compared with that of the larvæ. Though feeding almost entirely upon corn, they have occasionally been recorded as eating various weeds, clover, beans, cucumber- and squash-vines, apples of which the skin had been broken, cotton-flowers, pumpkins, and various fungi.

(*Remedy.*—See below.)

The Southern Corn Root-worm or Twelve-spotted Diabrotica (*Diabrotica duodecempunctata* Oliv.).

This beetle is distinguished from the above by being larger and having three transverse rows of four black spots on the wing-covers. Its larva, which has very similar habits and is very injurious, by eating the corn-roots in the South, has not been known to do so in the North, but is everywhere exceedingly abundant. The beetle is probably best known as attacking squash-, melon-, and cucumber-vines, of which it eats voraciously both leaves and fruit, but has also been noticed on clover, cabbage, cauliflower, beans, beets, hops, cotton, chrysanthemums, and various fruit-trees.

Remedy.—The remedy for both these pests is so simple and effective that it would seem that no one ought to suffer from their injury. As far as known, they have never been injurious to corn after a previous crop of wheat, rye, or barley, though the field may have been infested before that, and a crop of corn is then safe for at

least two years. Thus a simple rotation, which is also to be recommended on many other grounds, is entirely effectual.*

The Corn-root Web-worm (*Crambus caliginosellus* Clem.).

Injury.—When young corn-plants are seen to stop growing, become deformed, and to die off in such numbers as to frequently necessitate replanting, upon examination of the roots the injury will often be found to be due to the work of a small caterpillar. Two or three, very often five or six, and sometimes as many as eight or nine will be found at the base of a plant about an inch below the surface of the soil, and not over four to six inches from the stalk, usually being in close proximity to it. Each larva is covered with a fine, loose web, to which cling particles of earth, forming a sort of case, and on account of which these insects are known as Web-worms.

Where the web-worms are present in any number they will often necessitate the second, third, and sometimes a fourth planting, making the corn very late and involving considerable expense. The worms bore into the young stalks just above the ground, frequently cutting them off entirely. Later on the larger stalks are gouged out at or slightly above the surface of the ground, and the larvæ burrow into the folded leaves, which when they unfold have several transverse rows of three to five holes. On

---

* See :

1882. Forbes, S. A. First Ann. Rept. 12th Rept. St. Ent. Ill., p. 10.
1890. Forbes, S. A. 6th Ann. Rept., p. 71.
1892. " " 7th " " pp. 146, 154.
1894. Webster, F. M. Bull. No. 51 Ohio Ag. Exp. Sta., p. 89.
1896. " " " " 68 " " " " p. 39.

account of this habit these insects are sometimes known as "bud-worms." Strong plants will often make a new start and survive the injury, but remain much behind those not attacked, while most of the weaker plants will decay and rot off.

The Moth.—As one walks through pasture or grass land, many little white and yellowish moths are seen flying about on all sides, but quickly disappear as they alight on the grass. If a single individual be watched more closely, it will be noticed that in alighting upon a blade of grass it quickly rolls its wings very tightly around its body, and hugs up close to the grass so that it is hardly distinguishable from it. Projecting from the head in front is what appears to be a long beak or snout, on account of which these moths are often known as "snout-moths," but which really consists of the palpi or feelers. The "Grass-moths," as they are sometimes called, belong to the genus *Crambus* and include several common species, being marked with silver stripes and bands, as well as golden lines and markings, so that they often present a very handsome appearance.

Life-history.—These are the parents of the Web-worms which do so much injury to the young corn-roots, the principal depredators upon corn belonging to the species *Crambus caliginosellus.* They lay their eggs in grass land in May or early June, dropping them on the surface among the rubbish or vegetation, or attaching them to the grass. They are oval in form and of a yellowish color, each being marked with regularly placed ridges. About two hundred eggs are laid by each female. In from six to ten days the eggs hatch. The young larvæ soon form their loose silken webs or tubes at or a little below the surface of the soil,

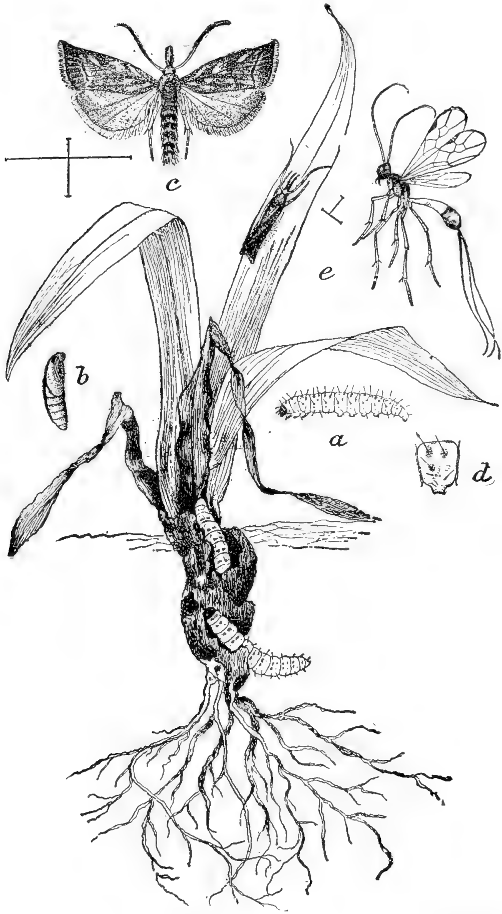

FIG. 73.—The Corn-root Web-worm (*Crambus caliginosellus*) *a*, larva; *b*, pupa; *c*, moth; *d*, segment of larva; *e*, parasite (After Johnson.)

burrowing among the roots, and feeding upon the stalk and outer leaves, or killing the plant by attacking the crown. The larvæ vary considerably in color, from a yellowish white, through pink, to a reddish or brownish shade, and are studded with small tubercles, each bearing a tuft of bristly hairs. The larvæ become full-grown in from five to seven weeks and are then from one-half to three-fourths of an inch long. During the latter part of July they form cocoons, sometimes in the larval tubes, in which they pass the pupal stage and from which the moths emerge some twelve to fifteen days later. Eggs are laid in grass lands during August and September for another brood, the larvæ hatching in September and October and becoming part-grown before winter. They hibernate in their webs over winter, and as soon as the grass commences its growth in the spring they are to be found feeding upon it, becoming full-grown early in May.

Preventive.—As the natural food of these insects is grass, it is not surprising that corn planted on sod land should be worst injured; and though the injury done the grass may not have been noticeable, when the available food is so greatly diminished by substituting for grass land the comparatively few hills of corn the injury becomes much more serious and apparent. Though the planting of corn on sod land is a most common practice, injury by this and many other insect pests of corn—most of whose native food is grass—might be avoided by planting any other crop than a grain, such as potatoes. Otherwise plowing late in the fall and harrowing so as to expose the larvæ to the weather, or plowing so deeply that they will be buried so that they cannot regain the surface, will do much to prevent injury the next season. Inasmuch as the moth will

not lay her eggs upon plowed land, if the land be plowed early she will be driven to other fields; but the exact time of oviposition varies for different latitudes.

Generous fertilization will aid the plants in overcoming injury very considerably. Dr. J. B. Smith advises "the application of all the necessary potash in the form of kainit, put on as a top-dressing after the field is prepared for planting," and says: "Fall plowing and kainit as a top-dressing in spring will, I feel convinced, destroy by all odds the greater proportion of the web-worms that infest the sod, and would also destroy or lessen many other pests which trouble corn during the early part of its life."

The Corn Root-louse (*Aphis maidi-radicis* Forbes).

Description.—Where patches of corn become dwarfed, the leaves becoming yellow and red, with a general lack of vigor, one may well be suspicious of the work of the Corn Root-louse. Though such an appearance may be due to the Root-blight or the Grass Root-louse (*Schizoneura panicola* Thos.), the cause of the trouble may usually be ascertained by an examination of the roots. If due to root-lice, they will be readily seen gathered together in large masses. The Root-louse may be recognized by being of a bluish-green color, with a white, waxy bloom, of an oval form, with two short, slender tubes projecting from the posterior part of the abdomen. These have open ends and were formerly supposed to excrete the sweet liquid "honey-dew" upon which the ants feed, and were therefore called "honey-tubes." If the Grass-louse be the depredator, however, it may be recognized by its white color, its blackish head and markings, and the absence of the honey-tubes, their position being indicated

by two small openings surrounded by narrow brownish rings. The latter species is common upon the roots of grasses, among which may be mentioned blue grass, timothy, and *Panicum glabrum*, and though it rarely becomes of any great economic importance, it is well to be able to distinguish it from the more injurious Corn Root-louse.

Distribution and Food.—The Corn Root-louse has been reported from Illinois, where it occurs in all parts of the State, Maryland, New Jersey, Delaware, Indiana, Ohio, Kentucky, Minnesota, and Nebraska, so that it doubtless occurs to some extent through the whole Corn Belt. Besides broom-corn and sorghum no other cultivated crop has been known to have been injured by this pest, though it feeds in early spring and even as late as June upon the roots of smartweed, purslane, *Portulaca soleracea*, ragweed, foxtail, and crab-grasses. The economic bearing of its feeding upon these weeds will be seen in discussing the life-history.

Care of the Ants.—If you will break open the nests of the small brown ants (*Lasius niger* and var. *alienus*), which are common in corn-fields which have been infested with the root-louse, during the winter, you will doubtless find many of the little black aphis-eggs, which have been carefully stored by the ants and which will be well cared for by them during the winter. They are of a glossy black color and an oval shape, and will sometimes be found in small piles in the chambers of the ants' nests. On warm days the ants bring them up to the warmer surface-soil, and in cold weather carry them far down into the unfrozen earth. With the appearance of the young smart-weed plants (*Polygonum persicaria*) in early spring, the

eggs commence to hatch. The ants at once lay bare the smartweed roots and carry their young wards to them, where large colonies soon become established.

Life-history.—If the field is not planted in corn, the lice will later feed upon the roots of the pigeon-grass or purslane. About the first of May the second generation of lice commences to appear, among them being both winged and wingless forms. Like most plant-lice, this brood, and all during the summer, are produced by females known as *agamic females*, without any intervention of the male form, the young lice being borne directly by the female without any egg stage. Such females are called viviparous in contrast to those laying eggs, which are called oviparous, and such a process is termed "budding" or *parthenogenesis*. The little brown ants again transfer the lice to the roots of the young corn-plants about this time, burrowing around the roots of the corn so as to lay them bare, and even carrying hither winged lice. All through the summer they attend the lice, burrowing around the roots of the corn, and carrying them from plant to plant, in return for which, upon stroking the lice with their antennæ, the lice give off the sweet "honey-dew" upon which the ants feed; indeed, the lice have been well likened to herds of cattle, cared for by the ant herdsmen. The first three generations each require about nineteen days to become full-grown. During the summer the lice continue breeding with extreme rapidity, the broods becoming mature in an average of eleven days, some twelve broods occurring before the middle of September. During the summer both winged and wingless agamic females occur, but about the middle of September appears a brood of wingless lice including both true sexes.

The females of this brood lay the eggs until the middle of November. This generation is usually carried by the ants to their nests, of which they are given the freedom and in which they lay their eggs.

Remedies.—Owing to the fact that the lice do not migrate until the second generation, a rotation of crops will be of considerable service in checking their injuries, as corn planted on uninfested land will not be attacked until it has been able to secure a good start, and if well fertilized may be able to successfully withstand the injuries of the lice. The proper fertilization of plants infested with root-insects is always of the greatest importance, and usually the corn-plant will readily throw out sufficient roots to enable it to mature a crop, if the soil contains sufficient nourishment and is under proper cultivation.

As the ants not only care for the lice during spring and summer, being largely responsible for their spread, but house the eggs in their nests over winter, any means by which the nests may be destroyed together with their inmates, the adult ants, their larvæ, and aphis-eggs, will therefore be of considerable value in controlling the lice. Deep fall plowing and harrowing, thoroughly breaking up the ants' nests just before early winter, has been found to accomplish this end to a large extent, and is also excellent practice for destroying the hibernating larvæ of cutworms and the Corn Stalk-borer. Furthermore, inasmuch as the lice feed upon various weeds in early spring, if these be kept cultivated out, the probability of injury to the corn will be greatly lessened. These weeds are usually thickest in low spots, and it is in just these places that the lice appear first and do their worst damage.

Injury done by the Corn Root-aphis is often overlooked

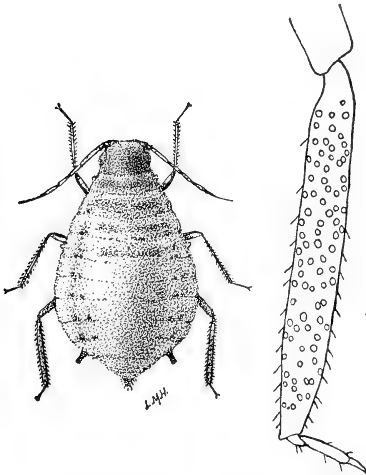

Fig. 74.—The Corn Root-aphis (*Aphis maidiradicis* Forbes); Oviparous female. *a*, hind tibia, showing sensoria. (After Forbes.)

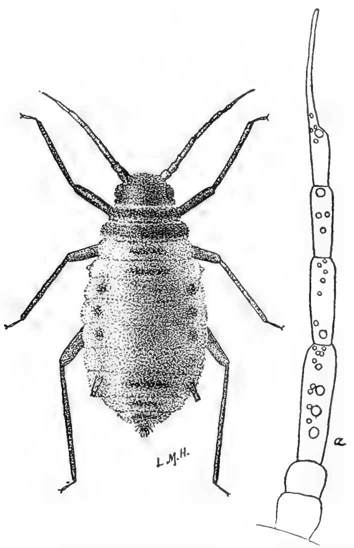

Fig. 75.—The Corn Root-aphis; male. *a*, antennæ. (After Forbes.)

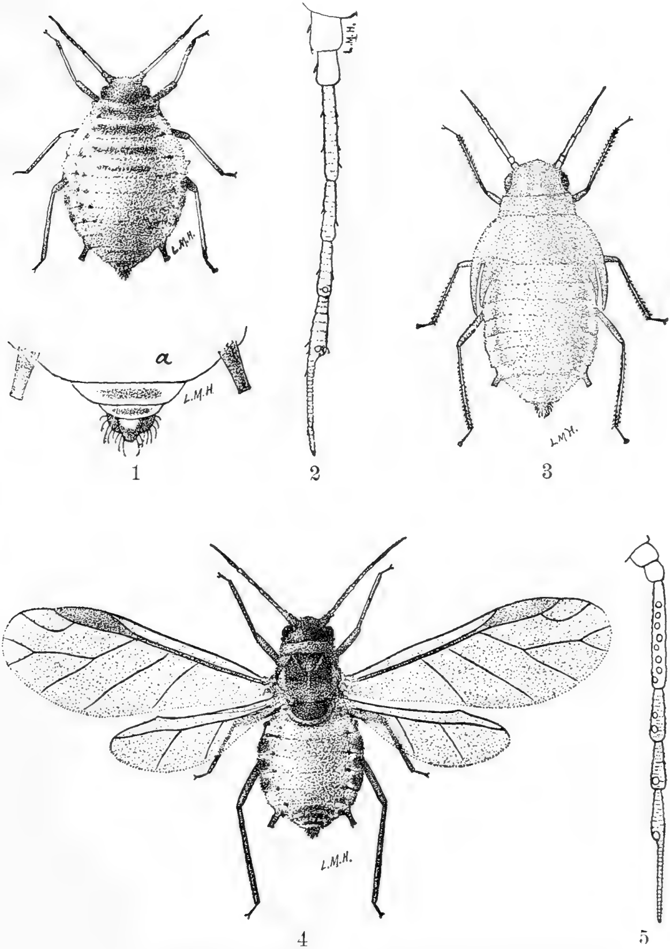

FIG. 76.—The Corn Root-aphis (*Aphis maidiradicis* Forbes). 1, wingless viviparous female; *a*, apex of abdomen; 2, antennæ of same; 3, pupa; 4, winged viviparous female; 5, antenna of same. (After Forbes.)

or attributed to other causes, as is much of that done by root-lice on other plants, largely on account of ignorance concerning it. From the above description of its life

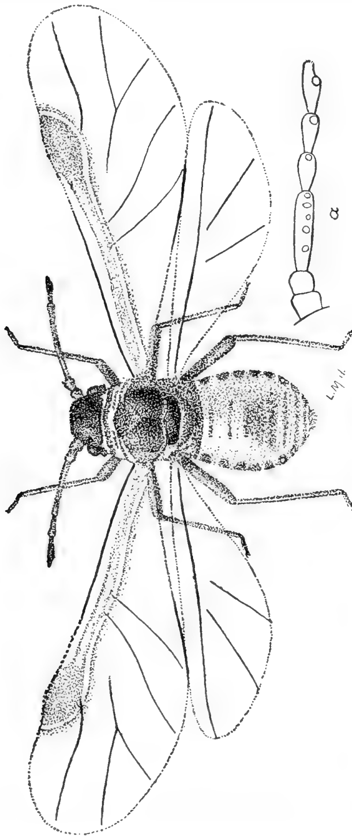

FIG. 77.—Grass Root-louse (*Schizoneura panicola*); winged viviparous female. *a*, antenna.

its destructive capacity may readily be seen, and also the weak points in its career, at which times it may be most successfully combated. With such a knowledge to guide us, the application of the cultural methods outlined is but

a simple matter, and a most practical and efficient method of dealing with this troublesome pest.

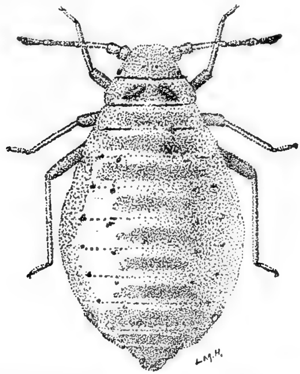

FIG. 78.—Grass Root-louse; wingless viviparous female. (After Forbes.)

INJURING THE STALK.

Corn Bill-bugs (*Sphenophorus* spp.).

Description.—Throughout the South and often in the more Northern States, Canada, and the West the Corn Bill-bugs sometimes become serious enemies of young corn-plants. They belong to the same class of "snout-beetles" as the Plum Curculio and Grain-weevil, and to the same family as the latter—the *Calandridæ.* They are called "Bill-bugs" on account of the prolongation of the head, termed a bill or snout, by means of which they are enabled to drill holes in the corn-stalks. Several species belonging to the genus *Sphenophorus* are commonly injurious to corn. One of these, *S. parvulus* Gyll., also attacks small grains and timothy, and is therefore known as the Grain Sphenophorus. Another species, *S. obscurus* Boisd., does considerable injury to sugar-cane in Hawaii.

The adult beetles are from one-fourth to three-fourths of an inch long, of the form shown in the illustration, and are of a brown or black color, marked with darker longitudinal ridges on the wing-covers. The larvæ are of from one-fourth to five-eighths of an inch long, thick fleshy white grubs, with brown heads and cervical shields on first segments, and footless.

Life-histories.—The life-histories of the different species are but partially known and vary somewhat.

S. parvulus hibernates over winter as a beetle, appearing in March and April. The female punctures the stalk of wheat or timothy—oats and barley are also sometimes attacked—a little above the roots, and deposits her egg in the cavity. This is done in May or June even up to July 1st. The larvæ are to be found during July, becoming full-grown and pupating during the latter part of that month. The larvæ will eat out quite a cavity in the interior of the stalk or bulb, and then attack the roots, thus often killing a whole clump or stool of small grain or timothy. The pupal stage is passed in a small cell in the earth and lasts from two to three weeks, adult beetles emerging from the middle of August to the first of October.

The life-history of *S. robustus* is not known, though larvæ and pupæ were collected in South Carolina on August 20th, and adults in early spring and late August. So far this species has been found only on corn. "Wherever," says Dr. Howard, "the larva had reached its full size the pith of the stalk was found completely eaten out for at least five inches. Below ground even the hard, external portions of the stalk were eaten through, and in one instance everything except the rootlets had dis-

appeared and the stalk had fallen to the ground. In a great majority of instances but a single larva was found in a stalk, but a few cases were found where two larvæ were at work. In no case had an ear filled on a stalk bored by this larva. The stalk was often stunted and twisted, and the lower leaves were invariably brown and twisted."

One of the most injurious species to corn is *S. ochreus* Lec. The life-history is much the same as that of *S. parvulus*, though eggs have been found as late as July 30th. The natural food-plant of this species, however, is the common Club-rush (*Scirpus fluviatilis*), the roots of which consist of bulbs connected by smaller slender roots. The eggs are deposited in or about the roots of this rush, never having been found on corn. The bulbs of the rush are very hard and oftentimes as large as hens' eggs. In them the larvæ burrow, becoming full-grown and transforming to pupæ, from which the adult beetles appear in August and September. When the rush becomes too hard for the beetles they often attack a common reed (*Phragmites communis*), piercing and splitting lengthwise the unfolded terminal leaves, and eating out the succulent portions within. The injury to corn is done by the beetles while the corn is still young, feeding upon it in the same manner as do the other species. "Standing with the head downward and the feet embracing the lower part of the stalk," says Dr. Forbes, "they slowly sink the beak into the plant, using the jaws to make the necessary perforation. By moving forward and backward and twisting to the right and left, the beetle will often hollow out a cavity beneath the surface much larger than the superficial injury will indicate." As the lower part of the stalk becomes hardened, they leave it for the terminal portion, and when

the ears commence to form often penetrate the husk and gorge out the soft cob. Sometimes the injury thus inflicted is but slight, merely resulting in a puncturing of the leaves when they unfold, these being in a series across the leaf resulting from a single puncture when the leaf was folded, and looking much like the work of the Corn Root-web-worm. But when several beetles attack a young plant,

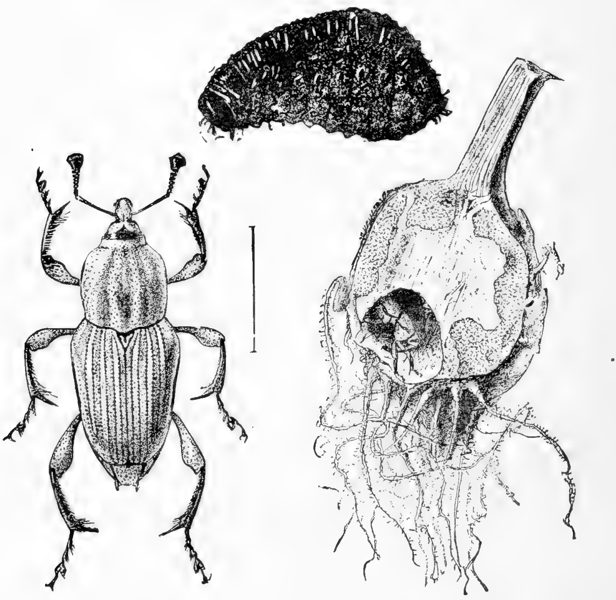

FIG. 79.—*S. ochreus*, larva, adult, and work in roots of *Scirpus*. (After Webster, "Insect Life.")

they will either kill it outright or so deform the foliage and stalk that no ear will mature.

Several other species have also been known to do more or less injury to corn, viz., *S. scoparius*, *placidus*, *cariosus*, *sculptilis*, and *pertinax*, but so far as known their habits and injuries are much the same as of those already described.

Means of Control.—The control of these pests is rather a difficult task. *S. robustus,* which breeds in corn and winters in a pupal cell in the roots and stalk as an adult

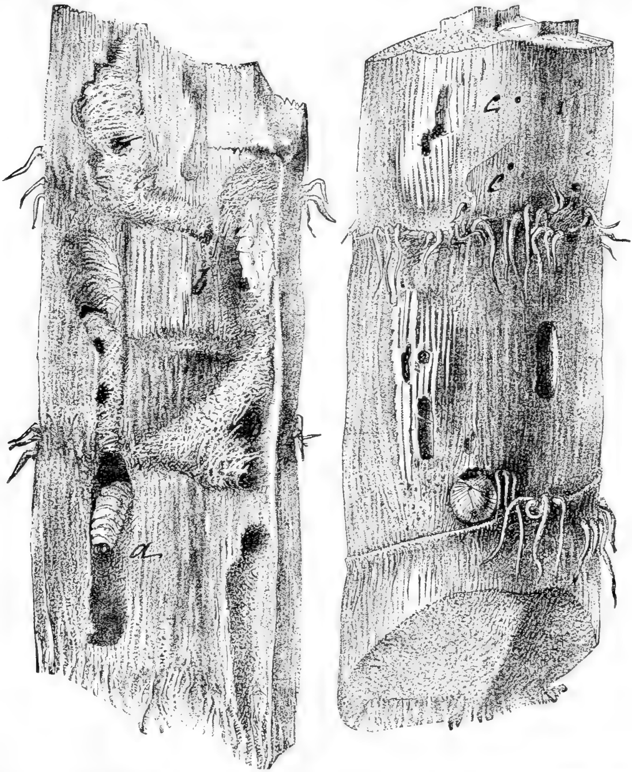

FIG. 80.—Sections of Sugar-cane showing work of *Sphenophorus obscurus.* *a,* larva; *b,* pupa; *c,* probable points of oviposition. (After Riley and Howard, "Insect Life.")

beetle, might be destroyed by plowing up and burning the stubble. *S. ochreus,* as are in fact all of the species, is most injurious on recently cleared swamp-land, and usually disappears as fast as these lands are drained and cultivated. Planting flax, potatoes, or some crop not attacked by these

insects for the first crop will largely prevent so serious injury to a subsequent corn crop. The burning over of grass- and swamp-land infested with the beetles will also be of considerable value.

The Larger Corn Stalk-borer (*Diatræa saccharalis* Fab.).*

Injury.—Every season corn throughout the district from Alabama to Maryland is more or less seriously injured by large, white, brown-spotted caterpillars, which bore into the stalks, especially the young stalks. When abundant a loss of from 25 to 50 per cent of the crop results. In Louisiana and the West Indies this pest is known as the Sugar-cane-borer. It is found as far west as Kansas, and is frequently injurious in the southern parts of Maryland, Delaware, and New Jersey.

Life-history.—In the fall when the caterpillars become full-grown they burrow down into the tap-root and there pass the winter in a small cavity at or near the surface of the ground. In the spring they transform to pupæ (Fig. 81), from which the adults soon emerge. The eggs are laid upon the leaves of the young corn near the axils, and the young larvæ hatching from them bore into the stalk and upward through the pith. As the borers grow they become very active and frequently leave and re-enter the stalk, thus making several holes. When the caterpillars are full-grown they bore outwards to the surface of the stalk, making a hole for the escape of the adult moth, and then transform to pupæ in the burrows. This takes place from the middle of July on, and the adult moths emerge from ten days to two weeks later. The second

* See L. O. Howard, Circular 16, n. s., Div. Entomology, U. S. Dept. Agriculture.

brood of larvæ feed on the old stalks, tunneling them between the second joint and the ground, and become full-grown about harvest-time, when they go into winter

FIG. 81.—Work of the larger Corn Stalk-borer. *a*, general appearance of stalk infested by the early generation of borers; *b*, same cut open to show pupa and larval burrow. (After Howard, U. S. Dept. Agr.)

quarters as already described. "The damage done by the second generation consists largely in weakening the stalk so that it is readily blown to the ground, whereas damage

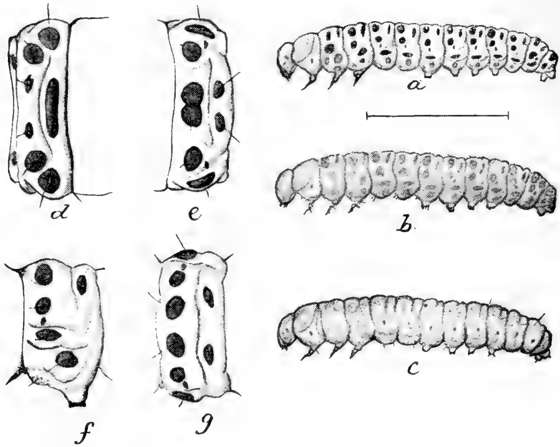

FIG. 82.—*a, b, c,* varieties of the larva of the larger Corn Stalk-borer; *d,* third thoracic segment; *e,* eighth abdominal segment; *f,* abdominal segment from side; *g,* same from above—enlarged. (After Howard, U. S. Dept. Agr.)

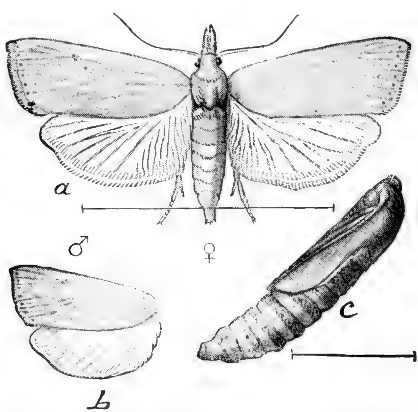

FIG. 83.—The larger Corn Stalk-borer. *a,* female; *b,* wings of male; *c,* pupa—all somewhat enlarged. (After Howard, U. S. Dept. Agr.)

by the first generation results in serious injury to the crop, preventing the growth of the ears."

Description.—When full-grown the larvæ are about three-fourths of an inch long, with six true legs and five pairs of pro-legs, and of a white color marked with brown as shown in Fig. 82. These brown markings often become indistinct or lost in larvæ hibernating over winter.

Preventive.—Dr. Howard states that "in 1891 it was found that of corn planted during the first and second weeks in April, 25 per cent was damaged; of that planted the third and fourth weeks, 20 per cent was damaged; of that planted May 1st to 15th, 15 per cent was damaged; of that planted May 15th to 31st, 12 per cent was damaged; of that planted from June 1st to 15th, 8 per cent or less was damaged. In fact, corn planted after the first of June was practically uninfested."

Remedies.—Where corn has been seriously infested the old stalks or butts should be dragged off the field and burned late in the fall, thus destroying the over-wintering borers. Where corn is stripped for fodder, the stalks left standing, and the land sown in small grain, the most favorable conditions are allowed the borers for safely passing the winter and developing into moths which will fly to new fields in the spring. Besides corn, sugar-cane, and sorghum, this insect also attacks a rank-growing grass which grows upon swampy land, known as Gama-grass, or Sesame-grass (*Tripsacum dactyloides*). Where such grass adjoins corn-fields, therefore, it would be well to burn it over in the summer. A simple rotation of crops will also do much to lessen the numbers of this pest. It has been observed by Dr. Howard that crops on fields planted in corn the previous year have been damaged to

the extent of 25 per cent, whereas injury to corn planted on sod land was only 10 per cent, though reasonably close to land which had been in corn.

Cutworms (*Noctuidæ*).

Almost all of our common cutworms attack young corn to a greater or less extent, sometimes doing considerable

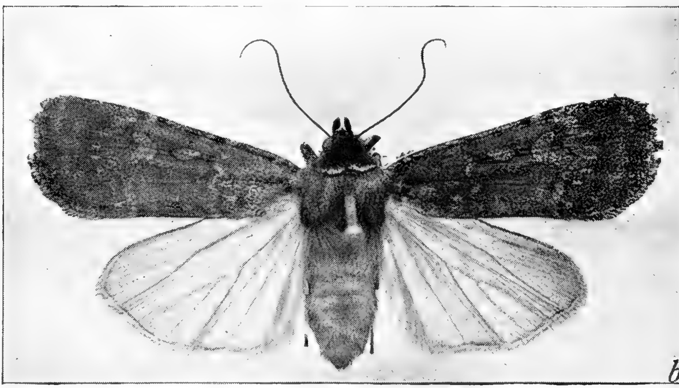

FIG. 84.—The Well-marked Cutworm-moth (*Noctua clandestina* Harris). (After Slingerland.)

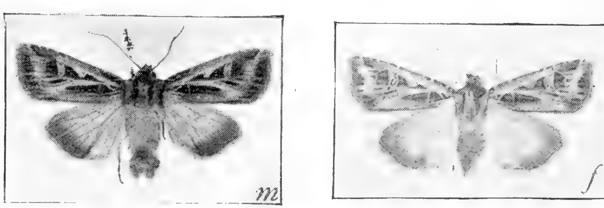

FIG. 85.—The Dingy Cutworm (*Feltia subgothica* Haworth); male and female moths. (After Slingerland.)

damage. The same species affect corn as tobacco, and the account given on page 214 is therefore equally applicable to corn cutworms. For large areas clover or grass might

be sprayed with an arsenite, then cut, and bunches of it scattered over the fields, as a poisoned bait, instead of the bran mash, being cheaper and more easily prepared and applied in large quantities.

INJURING THE EAR.

The Corn Ear-worm (*Heliothis armiger* Hubn.).

Practically the only insect seriously injuring the ears of field-corn, and the worst insect pest of sugar-corn, is the Ear-worm. In the extreme South the growing of sugar-corn successfully is almost an impossibility on account of the injury done by these worms, while further north it often reduces the profits by far too large an amount.

This insect also does considerable damage to tomatoes by boring into the green and ripening fruit, being known as the "Tomato Fruit-worm"; it bores into the "bud," or unfolding leaves, of tobacco, being known to planters as the "Tobacco Bud-worm" (see page 218); and is also one of the most serious pests of cotton (see page 201), being called the "Cotton Boll-worm" from its habit of boring into the boll. It also has many other food-plants and is a cosmopolitan insect, being found in many parts of the world.

Life-history.—In this latitude the moths appear during May and deposit their eggs on corn or other food-plants, such as beans. The eggs (Fig. 2) are small, yellow, circular, flattened disks, prettily corrugated by ridges radiating from the centre. They hatch in three or four days. When deposited upon corn they are usually laid in the silk or tassels. Upon hatching, the young worms, after feeding upon the silk for a day or two, find their way down into

the ear, where they feed upon the tip of the young ear. Very often one worm will feed upon several ears before it becomes full-grown, eating its way out through the husk,

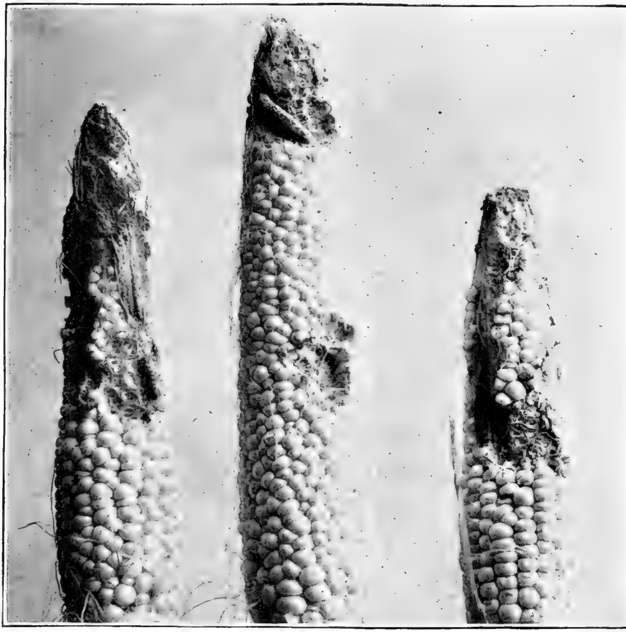

FIG. 86.—Corn Ear-worms at Work. The central cob has been attacked by a nearly full-grown worm, which has bored through the husk near the middle. (Original.)

in which it leaves a large round hole (Fig. 87), marking its exit. When full-grown the worms leave the ears and go into the ground, where, three or four inches below the surface, they hollow out small oval cells and in them transform to pupæ. From ten days to two weeks later the next brood of moths emerges. Thus the complete life-cycle is completed in about thirty-eight days, the exact time

varying with the latitude and season. In the South there are five broods in a year; in Delaware there are three

FIG. 87.—Corn Ear-worm. Husk of ear of sugar-corn torn open, showing worms at work on tip, and hole through which a full-grown worm has left. (Original.)

broods, further north but two, and in some sections possibly only one brood may occur. The second brood of

moths appears in northern Delaware about the middle of July, and the third brood during the first two weeks of September. In northern Delaware only the last brood of worms in September is injurious, but in the southern part of the State corn is injured at all seasons, but worst in July and September. In Delaware but little corn is canned after September 1st, but in Maryland, where it is canned until frost, the late corn is always more or less seriously injured.

Remedies.—As yet no thoroughly satisfactory method of combating this pest upon corn is known. As the pupæ of the last brood in the fall hibernate in the ground over winter, many of them may be killed by deep plowing late in the fall or early in the spring, but as the moths are strong fliers this probably would not appreciably lessen the number of worms unless generally practiced throughout a community. Evidently the time of planting is a point which should be carefully considered. As the moths prefer to lay their eggs on the silk, corn which is in silk when they emerge from the ground will be most seriously injured, while corn which has finished silking at that time will be but little injured. Thus a few days' difference in the time of planting may mean immunity from injury or serious loss. In this locality corn planted between the 15th and 22d or 23d of June—the exact dates varying with the season—escapes injury by the fall brood, but that planted later than this is more or less injured, the later plantings being injured worst. The time of appearance of the different broods in different localities is therefore a matter of considerable importance, and a careful study may show that by proper planting injury can be largely escaped.

CHAPTER VIII.

"WEEVIL" IN GRAIN.

THE enterprising farmer who stores his grain, awaiting a higher price, is often sadly disappointed, when he sells at the top of the market, to find that it has been so riddled by "weevil" that it brings no more than had it been sold previously.

The term "weevil" is rather a comprehensive one, being commonly applied to almost every insect infesting stored food-products. But only four species are commonly injurious in the farm-granary.

Grain-weevils.

Of these the Granary-weevil (*Calandra granaria* Linn.) and the Rice-weevil (*C. oryzæ*) (Fig. 88) are the most common and widely distributed. Both of these insects have infested grain from the most ancient times, so long, in fact, that the granary-weevil has lost the use of its wings and remains entirely indoors. They are small, brown beetles, from one-eighth to one-sixth of an inch in length, with long snouts which are of great service in boring into the kernels of grain. By means of them the females puncture the grain and then insert an egg in the cavity. The larva hatching from this is without legs, somewhat shorter than the adult, white in color, and of a very robust

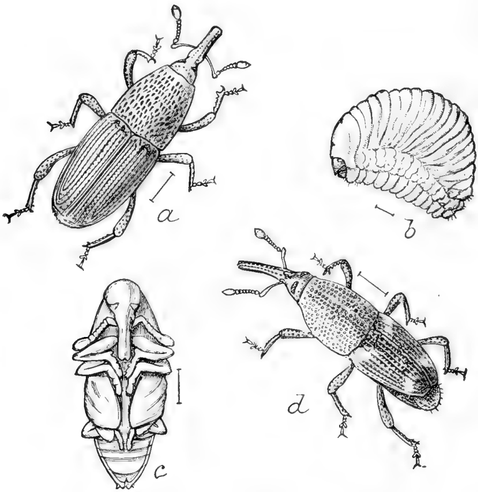

FIG. 88.—*Calandra granaria.* *a*, beetle; *b*, larva; *c*, pupa; *d*, *C. oryzæ*, beetle—all enlarged. (After Chittenden, U. S. Dept. Agr.)

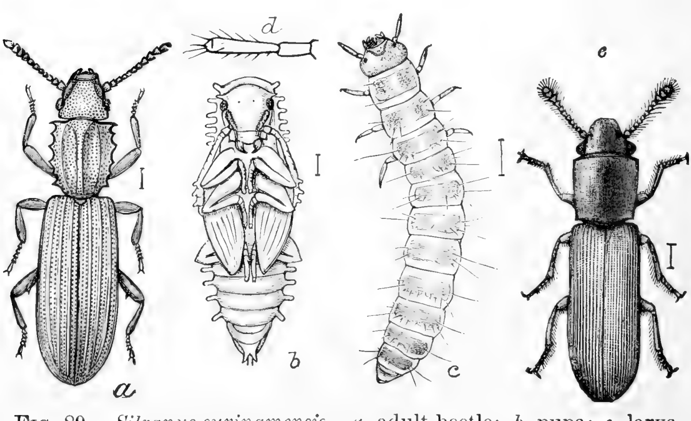

FIG. 89.—*Silvanus surinamensis.* *a*, adult beetle; *b*, pupa; *c*, larva—all enlarged; *d*, antenna of larva—still more enlarged; *e*, *Cathartus gemellatus.* (After Chittenden, U. S. Dept. Agr.)

build, being almost as broad as long. It soon devours the soft interior of the kernel and then changes to a pupa, from which the adult beetle emerges in about six weeks from the time the egg was laid.

Only a single larva inhabits a kernel of wheat, but several will often be found in that of corn. Not only do the larvæ injure the grain, but the beetles feed upon it, and then hollow out a shelter for themselves within the hull. The beetles are quite long-lived and thus do considerable damage. The egg-laying period is equally long, and as there are three or four broods in the North and six or more in the South, it has been estimated that the progeny of one pair would amount to 6000 insects in a single season.

Grain-beetles.

Another beetle very common in the granary, but of quite different appearance, is the Saw-toothed Grain-beetle (*Silvanus surinamensis* Linn.) (Fig. 89). It is a cosmopolitan pest and is also nearly omnivorous. The beetle is only about one-tenth of an inch long, very much flattened, of a dark-brown color, and may be easily recognized by the six saw-like teeth on each side of the thorax. The larva is of a dirty-white color, and quite dissimilar from that of the Granary-weevil. Having six legs to carry it about, it is not satisfied with a single seed, but runs about here and there, nibbling at several. When full-grown the larva glues together several grains or fragments into a little case, and inside of this transforms to the pupa and then to the beetle. In early spring this life-cycle requires from six to ten weeks, but in summer it is reduced to about twenty-five days. Thus there are from three to six or more generations during a season, according to the latitude.

The Red or Square-necked Grain-beetle (*Cathartus gemellatus* Duv.) (Fig. 89) is about the same size as the last species, but is of a reddish-brown color, and the thorax is nearly square, nearly as broad as the abdomen,

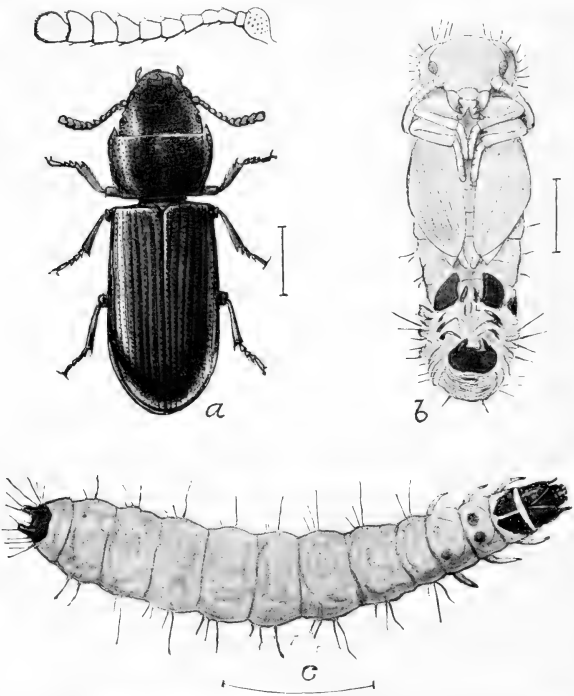

FIG. 90.—*Tenebroides mauritanicus.* *a*, adult beetle with greatly enlarged antenna above; *b*, pupa; *c*, larva—all enlarged. (After Chittenden, U. S. Dept. Agr.)

and not notched on the sides. It breeds in corn in the field and in the granary, first destroying the germ, so that it is especially injurious to seed-corn. It feeds mostly out of doors, though sometimes infesting the granary.

The Foreign Grain-beetle (*Cathartus advena* Waltl.) is

of much the same general appearance, but smaller and of a more robust appearance. It feeds upon a great variety of stored products as well as grain, but rarely becomes troublesome.

The Cadelle (*Tenebroides mauritanicus* Linn.) (Fig. 90) also has the bad habit of first attacking the embryo or germ of the kernel, and going from one kernel to another, thus destroying a large number for seed purposes. It possesses, however, the good trait of destroying other injurious grain-insects. The beetle is oblong, flat, nearly black, and about one-third of an inch long. The larva is of a whitish color, with brown head, the thoracic segments marked with brown, and the abdomen terminating in two dark horny processes. It is a long fleshy grub, nearly three-fourths of an inch long when full-grown.

Flour- and Meal-moths.

The larvæ of several small moths sometimes infest grain in store, but rarely do it serious damage, preferring the softer flour, meal, and food-products.

The most destructive of these is the Mediterranean Flour-moth (*Ephestia kuehniella* Zell.) (Fig. 91). This insect was practically unknown until 1877, but during recent years it has occasioned the loss of many thousands of dollars to mill-owners. It occurs throughout Europe, and is found in Mexico and Chili. It was first recognized in America in 1889, and has since done an increasing amount of damage in California, in New York and Pennsylvania, while it has been reported as occurring in North Carolina, Alabama, New Mexico, and Colorado, and seems to be constantly spreading. "The caterpillars form cylindrical silken tubes in which they feed, and it is in great part

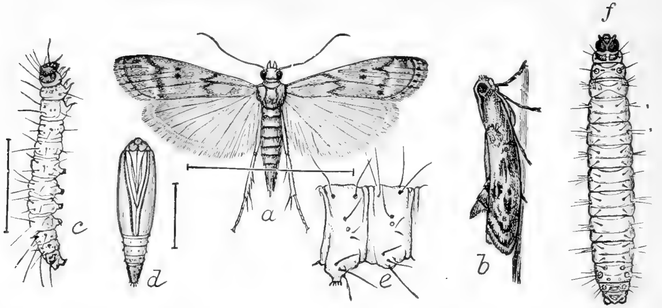

FIG. 91.—*Ephestia kuehniella.* *a*, moth; *b*, same from side, resting; *c*, larva; *d*, pupa—enlarged; *e*, abdominal joint of larva—more enlarged; *f*, larva, dorsal view. (After Chittenden, U. S. Dept. Agr.)

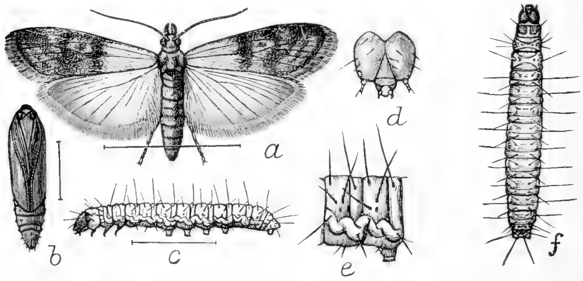

FIG. 92.—*Plodia interpunctella.* *a*, moth; *b*, chrysalis; *c*, caterpillar; *f*, same, dorsal view—somewhat enlarged; *d*, head, and *e*, first abdominal segment of caterpillar—more enlarged. (After Chittenden, U. S. Dept. Agr.)

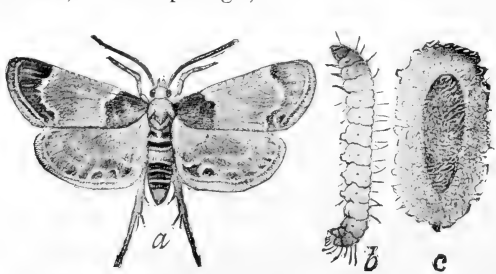

FIG. 93.—*Pyralis farinalis.* *a*, adult moth; *b*, larva; *c*, pupa in cocoon—twice natural size. (After Chittenden, U. S. Dept. Agr.)

their habit of web-spinning that renders them so injurious where they obtain a foothold. Upon attaining full growth the caterpillar leaves its original silken domicile and forms a new web, which becomes a cocoon in which to undergo its transformations to pupa and imago. It is while searching for a suitable place for transformation that the insect is most troublesome. The infested flour becomes felted together and lumpy, the machinery becomes clogged, necessitating frequent and prolonged stoppage, and resulting in a short time in the loss of thousands of dollars in large establishments." *

The life-cycle of this insect requires ordinarily about two months, but may be completed in thirty-eight days under the most favorable conditions. The adult moth measures a little less than an inch across the expanded wings. The fore wings are of a lead-gray color, with transverse black markings, while the hind wings are dirty whitish, with a darker border.

The Indian Meal-moth (*Plodia interpunctella* Hbn.) (Fig. 92) larvæ resemble those of the grain-beetles in having a special liking for the embryo of wheat-grains. They spin a fine silken web as they go from seed to seed, to which they become attached, and to which is added a large amount of excrement, thus spoiling for food much more grain than is actually injured.

The moth has a wing-expanse of an inch; the inner third of the fore wings being a whitish gray, and the outer portion reddish brown, with a coppery lustre.

The Meal Snout-moth (*Pyralis farinalis* Linn.) (Fig. 93) is of a light-brown color, the thorax, base, and tips of

---

* "Some Insects Injurious to Stored Grain," U. S. Dept. Agr., Farmers' Bulletin, No. 45, F. H. Chittenden.

the fore wings being darker brown. The wings expand nearly an inch and are otherwise marked with whitish lines as shown in the figure. It is very similar to the last-mentioned species in its habits, constructing long tubes with silk and particles of the food in which it is living. The life-history is completed in about eight weeks, and four generations may occur in a year. The moisture of "heated" grain is most favorable for the development of this pest, and it need not be feared if grain is kept in a clean, dry place.

The Angumois Grain-moth.

By far the worst granary pest throughout the South is the "Fly-weevil," or Angumois Grain-moth (*Sistotroga cerealella* Oliv.).

History.—This insect is an importation from Europe and receives its name from the fact that in 1760 it "was found to swarm in all the wheat-fields and granaries of Angumois and of the neighboring provinces [of France], the afflicted inhabitants being thereby deprived of their principal staple, and threatened with famine and pestilence from want of wholesome bread." The insect was first noted in this country in North Carolina in 1730, and in 1796 was so abundant as to extinguish a lighted candle when a granary was entered at night. It is essentially a southern insect, in the Gulf States being very injurious to stored corn. Of late years it seems to be moving steadily northward, being reported as injurious in central Pennsylvania and Ohio. Wheat, corn, oats, rye, barley, sorghum-seed, and even cow-peas are subject to injury.

Life-history.—The injury is not done by the moth, as might be reasonably supposed from the fact that it is the

only form of the insect usually seen, but is done by the small caterpillars which feed within the grain, where they may be found during the winter. The caterpillar eats to the surface of the kernel, but not through it, thus leaving a thin lid which the moth can easily push aside when it comes out in the spring, and then covers itself with a fine silken web. At this time the caterpillar is usually fully grown and is about one-fifth of an inch long, of a white color, with the head yellowish and harder, having six jointed legs in front, a series of four pairs of fleshy pro-legs along the middle, and another pair of soft legs at the end of the body. With warm spring weather the caterpillar changes to a pupa, and about the time that the wheat comes into head the adult moth emerges. As soon as it emerges, whether outdoors or in a barn, the moth at once flies to the grain-field, where the eggs are deposited. The exact time at which the moths emerge varies, but occurs some time late in May or in June. The moths quite closely resemble the clothes-moths often found flying about houses. The wings are quite narrow, and when expanded measure about one-half an inch from tip to tip, being of a yellowish or buff color, marked with black. The eggs are laid in the longitudinal channel on the side of the grain. Each female lays from sixty to ninety eggs in lots of about twenty each, one lot thus being about enough to infest the kernels of a head. The eggs hatch in from four to seven days. The young caterpillars are at first very active and soon find tender places and bore into the kernels, leaving almost invisible openings. These caterpillars become full-grown in about three weeks, just about the time the grain is mature. About harvest-time the second brood of moths appear. These lay their eggs

during July, depositing them on the ripe heads if the harvest be a little delayed, but on the wheat in stack if harvest is prompt. Usually the caterpillars hatching from these eggs become full-grown and remain in the grain over winter, but in warm seasons, especially if warm in September, and when the pest is unusually abundant, a third brood of moths appear early in September. These lay another batch of eggs about the middle of September, depositing them upon the open ends of grain in stack or

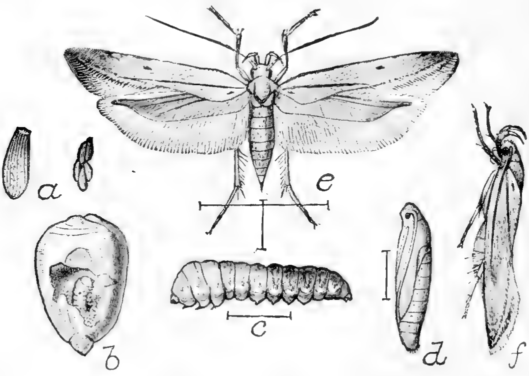

FIG. 94.—*Sitotroga cerealella.* *a*, eggs; *b*, larva at work; *c*, larva, side view; *d*, pupa, *e*, moth; *f*, same, side view. (After Chittenden, U. S. Dept. Agr.)

mow, which thus becomes more infested than that in the centre. In grain stacked outside, the caterpillars of this brood become full-grown slowly and remain in the grain over winter, but if in the mow they grow faster and a fourth brood of moths appear about the middle of October, the moths being noticed in threshing. The insects continue to breed within doors all winter as long as any grain remains, though they become sluggish and cease feeding during a very cold spell. The number of

broods is entirely dependent upon the latitude and weather conditions; in the South, where they can breed continuously, there being as many as eight in a year.

Corn is frequently attacked, but not until it is ripe and husked, and then but rarely when husked in October and November and stored outdoors in slatted cribs. Seed-corn stored in barns, and in the South in almost any situation, is often badly injured.

Aside from loss in weight, grain when badly infested becomes unfit for milling purposes, and will even be refused by cattle and horses, which should not be urged to eat it. In that case hogs and fowls will readily consume it.

Remedies.—Dr. J. B. Smith, in an interesting bulletin upon this pest, to which we are indebted for much of the above, advises as follows: "Thresh as soon after harvest as possible, and bulk in tight bins or in good sacks. [By "tight bins" are meant those which will not permit the entrance or exit of the moths.] If the grain is dry when

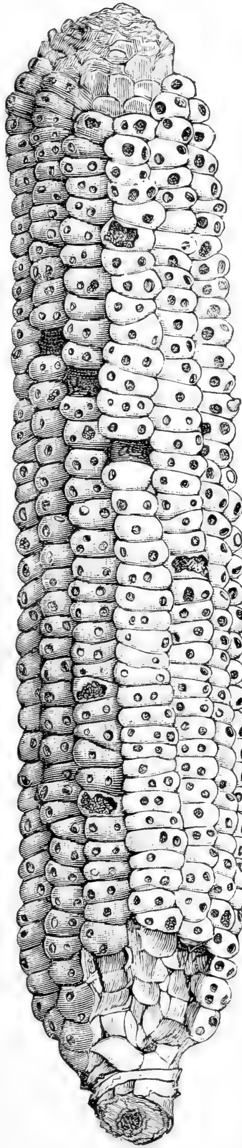

FIG. 95.—Ear of Pop-corn, showing work of Angumois Grain-moth. (After Riley.)

harvested, it may be threshed at once; if not, as soon as it is in good condition. If the sacked grain is infested, there will not be wormy kernels sufficient to heat the grain. The moths cannot make their way out and are stifled. Nothing can come in from outside and the grain remains safe. The threshing itself kills many of the insects and jars and rubs off many of the eggs. If binned, the bins should be *tight* and the grain should be tested occasionally for any appreciable heating. If it heats perceptibly, it indicates considerable infestation, and it should be treated with carbon bisulfide at once, used at the rate of one drachm per cubic foot, or one pound for 250 cubic feet bin-space." We have sometimes found two or three pounds for 100 bushels of grain necessary, though one or one and one-half pounds for 100 bushels has been often recommended. The bisulfide should be placed in shallow plates or pans on top of the grain, preferably not over a pound in a vessel, and the bin should then be covered with boards, canvas, or blankets, and allowed to remain at least twenty-four hours. If to be used for seed, it should not be left for over thirty-six hours; but if not, leave it forty-eight hours, which will do it no injury for food. After treating keep the grain covered to prevent reinfestation.

Those having wheat unthreshed, whether in stack or mow, should thresh at once, and treat as above directed, except that if much of it is noticed to be wormy, it should be treated with carbon bisulfide at once, as soon as threshed, which if done thoroughly will prevent any further infestation this year.

Barns and storehouses should be cleaned up and freed from all loose and scattered grain—chickens will help in this—before April 1st, so that no moths will be allowed to

develop and infest the grain in the field. Places where grain has been in shock the previous season should be cleaned up by the aid of chickens. Thus if there is any probability of grain being infested, it should be kept tightly covered in the spring so as not to permit the spread of the moths to the fields.

Prevention of "Weevil."—Undoubtedly grain-insects can usually be more successfully combated by a proper housing of the grain. No matter how often the insects in a granary are destroyed, if the remainder of the barn is full of dust, sweepings, and refuse, as it generally is, on which the beetles can feed and in which they will breed, and if the granary is not absolutely tight, as soon as the gas passes off the insects from the barn will again enter the granary, and soon it will be as badly infested as ever.

Cleanliness.—"Cleanliness will accomplish much toward the prevention of injury from these pests, the cause of a great proportion of injuries in granaries, mills, elevators, and other structures where grain and feed are stored being directly traceable to a disregard of neatness. Dust, dirt, rubbish, and refuse material containing sweepings of grain, flour, and meal are too frequently permitted to accumulate and serve as breeding-places for a multitude of injurious insects.

"The floors or corners and walls of the barn or store-house should be frequently swept, and all material that has no commercial value burned."

The Granary.—"The ideal farmer's granary, from the standpoint of insect ravages, should be built at some distance from other buildings, and the rooms constructed of matched flooring so as to be as near vermin-proof as possible. The doors should fit tightly, closing upon a rabbet,

which may be covered with felt or packing, and the windows covered with frames of wire gauze to prevent the passage of insects. The floor, walls, and ceilings should be smooth, so as not to afford any lurking-places for the insects, and it would be well to have them oiled, painted, or whitewashed for further security. A coating of coal-tar has been strongly recommended for the latter purpose."

"The value of a cool place as a repository of grain has been known of old, and a building in which any artificial heat is employed is undesirable for grain storage. The 'heating' and fermentation of grain, as is well known, is productive of 'weevil,' and this should be prevented by avoiding moisture and by ventilation.

"*The storage of grain in large bulk* is to be commended, as the surface layers only are exposed to infestation. This practice is particularly valuable against the moths, which do not penetrate far beneath the surface. Frequent agitation of the grain is also destructive to the moths, as they are unable to extricate themselves from a large mass, and perish in the attempt. The true granary-weevils (small dark-brown beetles with long curved snouts, similar to the pea-weevil), however, penetrate more deeply, and although bulking is of value against them, it is not advisable to stir the grain, as it merely distributes them more thoroughly through the mass."

Destruction of "Weevil."

Carbon Bisulfide.—"The simplest, most effective, and most inexpensive remedy for all insects that affect stored grain and other stored products is the bisulfide of carbon, a colorless liquid, with a strong disagreeable odor, which,

however, soon passes away." At ordinary temperature it vaporizes rapidly, forming a heavy gas, which is highly inflammable and a powerful poison.

Application.—It may be applied directly to the infested grain or seed without injury to its edible or germinative principles by spraying with an ordinary watering-can having a fine rose nozzle. In moderately tight bins it is more effective, however, evaporating more slowly and diffusing more evenly, if placed in shallow dishes or pans, or on bits of cloth or cotton waste distributed about on the surface of the grain or infested material. The liquid volatilizes rapidly, and, being heavier than air, descends and permeates the mass of grain, killing all insects and other vermin present.

Amount to Use.—The bisulfide is usually evaporated in vessels containing one-fourth or one-half of a pound each, and is applied in tight bins at the rate of one to three pounds to 100 bushels of grain, and in more open bins a larger quantity is used. For smaller masses of grain or other material an ounce is evaporated to every 100 pounds of the infested matter. Bins may be rendered nearly air-tight by covering with cloths, blankets, or canvas.

The amount of bisulfide to be used depends very largely upon the shape of the space to be fumigated. If the grain is in approximately a cubical form, the above amounts will be sufficient; but if spread out with but little depth, two to four or five times as much will be found necessary.

Time to Fumigate.—"Infested grain is generally subjected to the bisulfide treatment for twenty-four hours, but may be exposed much longer without harming it for milling purposes. If not exposed for more than thirty-six

hours, its germinating power will be unimpaired. In open cribs and badly infested buildings it may sometimes be necessary to use a double quantity of the reagent and repeat treatment at intervals of about six weeks during the warmest weather."

When possible it is always desirable to fan the grain immediately after fumination, thus removing the dead insects, and to thoroughly clean the granary before refilling it.

"Mills and other buildings, when found to be infested throughout, may be thoroughly fumigated and rid of insects by a liberal use of the same chemical. A good time for this work is during daylight on a Saturday afternoon or early Sunday morning, closing the doors and windows as tightly as possible and observing the precaution of stationing a watchman without to prevent any one from entering. It is best to begin in the lower story and work upward to escape the settling gas. The building should then be thoroughly aired, and the grain stirred early Monday morning.

"For the fumigation of a building or a reasonably close room it is customary to evaporate a pound of bisulfide for every thousand feet of cubic space. In comparatively empty rooms, and in such as do not admit of being tightly closed, two or three times the above quantity of the chemical is sometimes necessary.

Caution. — "Certain precautions should always be observed. The vapor of bisulfide is deadly to all forms of animal life if inhaled in sufficient quantity, but there is no danger in inhaling a small amount. The vapor is highly inflammable, but with proper care that no fire of any kind, as, for example, a lighted cigar, lantern, or light of any

kind, be brought into the vicinity until the fumes have entirely passed away, no trouble will be experienced."

Cost.—Carbon bisulfide may be secured through any retail or wholesale druggist in cans of various sizes. In considerable quantities it may usually be secured from wholesale houses and manufacturers at from 8 to 10 cents per pound, and in smaller quantities from retailers at 15 or 20 cents.

CHAPTER IX.

INSECTS INJURIOUS TO CLOVER.

Both for its value as forage and as a fertilizer, clover holds a peculiar place among our crops. In the Mississippi Valley and the Eastern States we have nothing to occupy its place, and without it the farmer would be at a loss to make a suitable rotation of crops.

Some eighty-two insects have been noted as doing more or less injury to the clover-plant, but hardly a dozen of these can be considered as serious pests. The insects doing the most injury to clover have so far not become widely spread and are largely confined to certain States and latitudes. But in these sections they have often been exceedingly destructive, and they seem to be constantly spreading.

INJURING THE ROOT.

The Clover Root-borer (*Hylastes obscurus* Marsh).

This is the only serious pest preying upon the roots, but on account of the difficulty with which it is fought makes a formidable opposition to the successful growth of the crop. Thus in the southern part of Michigan hardly one-half a crop was secured in 1894 on account of its ravages. Though the beetles have been well known in Europe for over a century, their habits there seem to be but little

understood. In this country the pest has been noticed since 1876, when it was first found in three counties in western New York. Since then it has been noted as doing injury on Long Island and in several parts of Canada. Some ten years later it appeared in Michigan, and in 1894 was found in northwestern Ohio. Thus it has not become very generally distributed, and seems to be confined to the Northern States.

Life-history.—If one tears open a clover-root in an infested field during the winter, he will usually find the beetles hibernating in the burrows. They will not be readily distinguished, as they are scarcely an eighth of an inch long and are of a reddish-brown color much like that of the burrow. With the warmer weather of spring they commence burrowing and feeding in the roots, and during the latter part of May the females deposit their eggs along the sides of the tunnels. The eggs are shining white, and are placed in the sides of the galleries and then covered and packed with refuse, so as to separate them from the rest of the burrow. In a few days the eggs hatch, and the small white grubs emerge and continue the attack upon the roots. Here they grow fat during the summer months and ultimately transform to pupæ, which again change to beetles during the early fall. This life-history varies considerably, and the grubs are often found much earlier and the beetles much later than usual. The spread of the insect occurs very largely in the spring when the beetles fly from field to field, seeking uninfested plants in which to perpetuate their kind. Their entrance is usually made below the surface of the ground, though sometimes the burrow is started from the crown of the plant.

It has been observed that alsike clover is not so badly

injured as the mammoth and common red, on account of its fibrous roots and the tendency of its tap-root to divide.

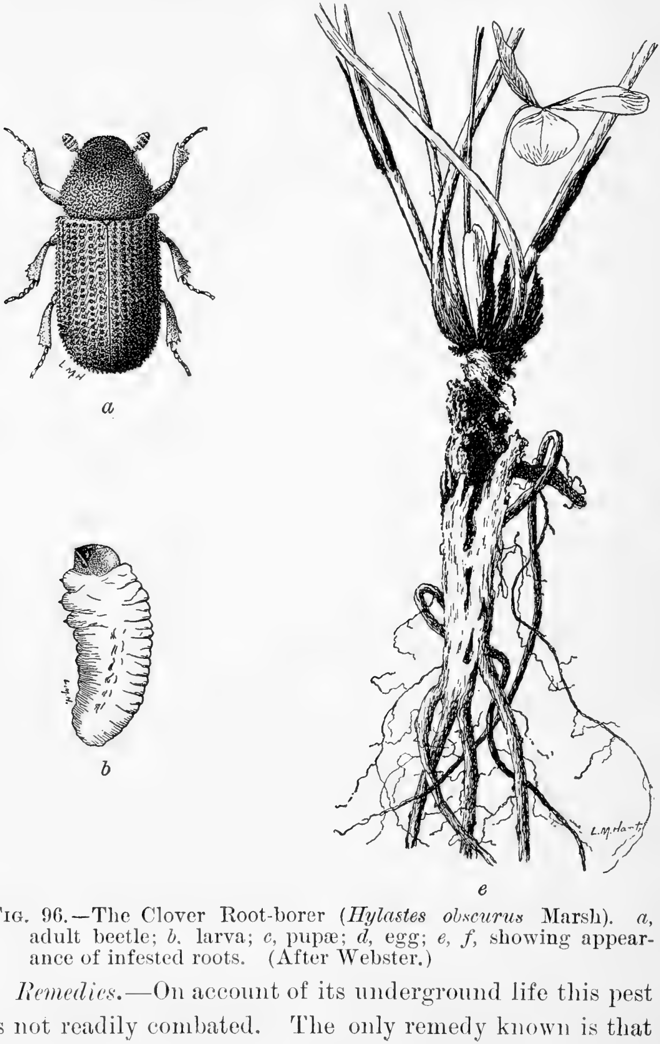

Fig. 96.—The Clover Root-borer (*Hylastes obscurus* Marsh). *a*, adult beetle; *b*. larva; *c*, pupæ; *d*, egg; *e*, *f*, showing appearance of infested roots. (After Webster.)

Remedies.—On account of its underground life this pest is not readily combated. The only remedy known is that

suggested by Prof. F. M. Webster, who advises "plowing the infested fields as soon as the hay crop is removed and

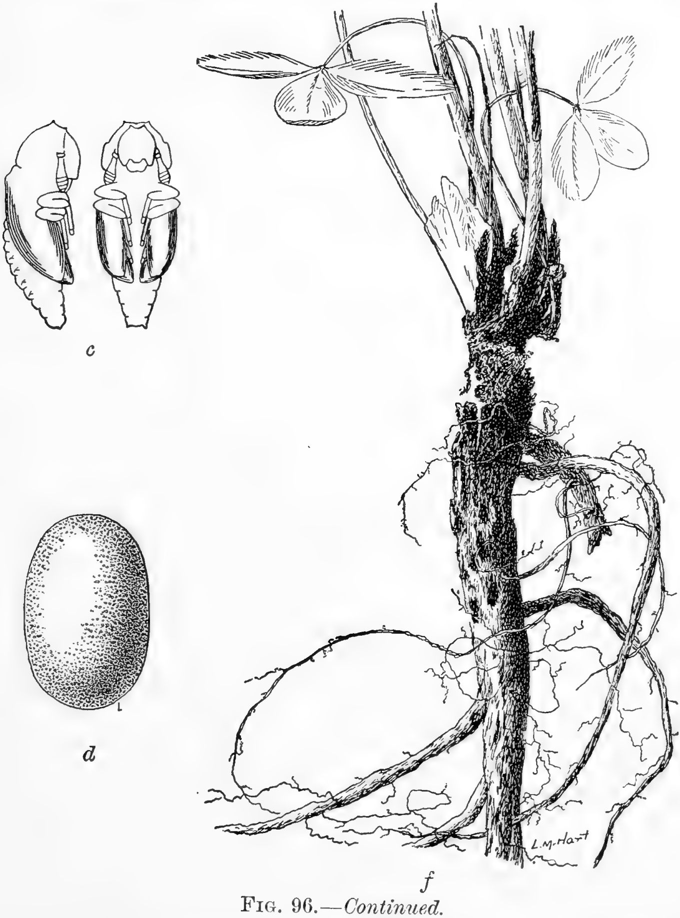

FIG. 96.—*Continued.*

before the larvæ have advanced to the pupal stage. If the roots are thrown up to the hot sun and dry winds at this time, they will dry out and thus starve the young larvæ,

thereby preventing their developing and migrating to other fields." A more frequent and thorough rotation of the crop will thus be of value.

Meadow-maggots. (See page 90.)

INJURING THE STEM.

The Clover Stem-borer (*Languria mozardi* Fab.).

Early in June one frequently finds the beetles of the Clover Stem-borer here and there in the clover-field. They are slender, shining beetles, about one-third of an inch long, with red head and thorax and bluish-black

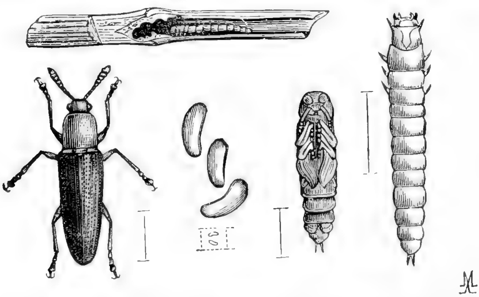

FIG. 97.—Clover Stem-borer (*Languria mozardi*). Shows the eggs natural size and magnified, the beetle, larva, and pupa much enlarged, and above, a clover-stem with the larva at work in it. (After Comstock.)

wing-covers. The beetles themselves seem to do little or no harm. Hibernating over winter, they lay the eggs in the pith of the stems early in June, and the larvæ emerging from these feed upon the pith of the stem, often very seriously weakening or killing it. The larvæ become full-grown in a short time, transform to pupæ, and the beetles appear by August.

Clover is only one of a dozen food-plants of this insect, which is widely distributed. It rarely does any consider-

able injury where clover is regularly cut in early summer and fall, and need not be feared when this is not neglected.

INJURING THE LEAVES.

The Clover Leaf-weevil (*Phytonomus punctatus* Fab.).

The Clover Leaf-weevil is also a native of Europe, and made its first appearance in this country in the same sec-

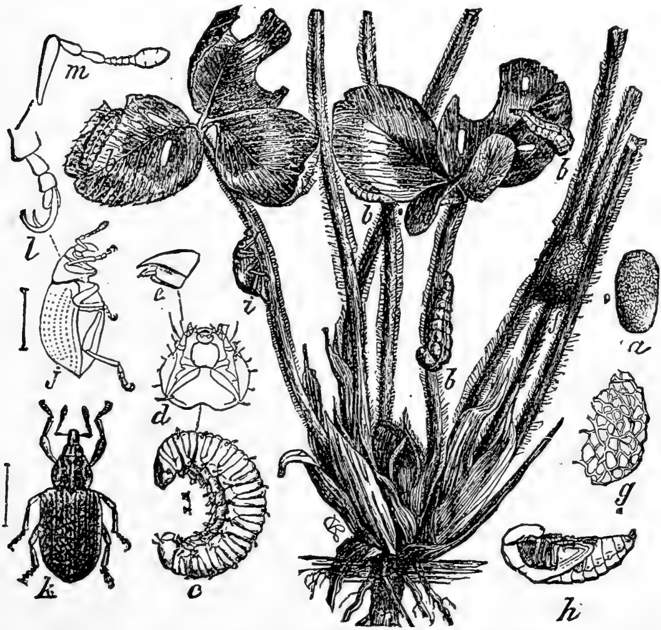

FIG. 98.—Clover Leaf-weevil (*Phytonomus punctatus* Fabr.). *a*, egg magnified and natural size; *b b b b*, larvæ; *c*, recently hatched larva; *d*, head of larva; *e*, jaws of the same; *f*, cocoon; *g*, same magnified to show the meshes; *h*, pupa; *i*, weevil, natural size; *j*, the same magnified; *k*, top view of the beetle; *l*, tarsus and claws of the beetle; *m*, antenna of the beetle. (After Riley.)

tion of western New York as the root-borer, in 1881. Its injuries during that and the following year seem to have been the worst on record. Since then it has spread east

into Connecticut, south to Maryland and West Virginia and as far west as Ohio and Michigan. Every few years the weevils and larvæ destroy much of the foliage, but rarely are as bad the next season. The weevil is about one-third of an inch long, of a stout, oval form, with a long, thick snout. It is of a brown color, with several narrow gray lines above and broad gray stripes on each side, and with twenty rows of small, deep punctures on the wing-covers.

Life-history.—In early fall the females lay their eggs in crevices among the stems near the base of the plant. The young larvæ emerging from them are without legs, but manage to climb quite well by means of the prominent tubercles on the lower surface of the body. They are light yellowish green, which usually becomes deeper green as they grow older. The larvæ become partially grown before winter sets in, when they go into a dormant stage, hiding in rubbish or under the soil till spring, when they continue to feed upon the foliage and become full-grown in May and June. The larvæ feed mostly at night and will not be noticed during the day, when they lie protected around the base of the plant. The injury done to the foliage is very characteristic, the edges of the leaves being eaten in a very regular manner as shown in the illustration. Before transforming to the pupa the larva constructs a very delicate cocoon of a greenish-yellow color, which is left on the surface of the ground. In this the pupal stage is passed, occupying about a month, the beetles being most common in July and August. The damage which the beetles do to the second crop of clover is fully equal that done by the larvæ to the first, and is more apparent, because the soil is then dry and the plant makes a slower growth. In

some cases the beetles have been known to hibernate over winter, when the larvæ would occur correspondingly earlier.

Enemies.—The reason that this insect has not become a more serious pest is, that as often as it becomes excessively abundant the larvæ are attacked by a fungous disease which carries them off by the millions. When affected by this they climb to the top of a blade of grass, curl tightly around the tip, and soon die, first becoming covered with a white mold and then turning to a jelly-like mass. The spores of the fungus become scattered to healthy individuals, which soon succumb. Larvæ affected in this manner may be easily recognized, and when diseased larvæ are found in any quantity care should be taken not to pasture cattle on land infested with them, as instances are on record in which there seems little doubt that cattle have been seriously poisoned by eating these diseased larvæ.

The Clover-mite (*Bryobia pratensis*).

The spraying of fruit-trees for various insect-pests in winter has been found to be one of the best means of keeping in control those which hibernate or whose eggs are on the trees during that season. One of these is the Clover-mite (*Bryobia pratensis*), an insect widely distributed and of most variable habits.

As its name indicates, this insect is nearly related to the common red spider of greenhouses, belonging to the family of vegetable-feeding mites (*Tetranychidæ*), and with which it is often confused. It is, however, about twice the size of the red spider, being fully three-tenths of an inch long.

Though known as the Clover-mite, on account of its feeding upon that plant, yet this insect was first known

as, and is still, an important enemy of fruit-trees, more especially on the Pacific coast and in the Western States, but also in other sections of the country. The most injury seems to have been done to clover in the Central States as far south as Tennessee, though it has suffered somewhat even in the East.

When attacked by the mite the leaves of the clover or fruit-trees become yellow and have a sickly appearance, as

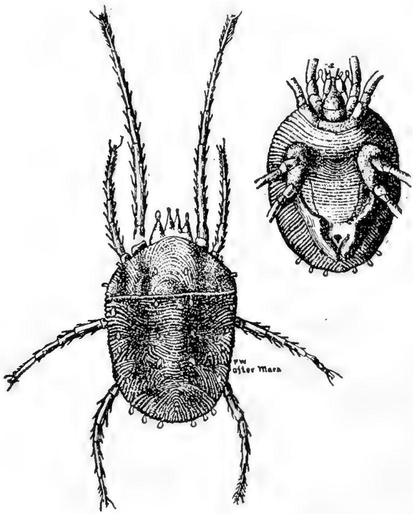

FIG. 99.—The Clover-mite (*Bryobia pratensis*).

if affected with a fungous disease. Especially upon the upper sides of the tender leaves of clover the juices are extracted over irregular areas, looking more or less like the burrows of some leaf-mining larvæ. Owing to the small size of the mites they may be doing considerable damage to the foliage and yet remain unnoticed; but in the egg stage the pest is much more readily detected and

attacked. In the more northern States the eggs are laid in the fall, and do not hatch until the next spring. Further south, however, the adult mites hibernate over winter. The eggs are of a reddish color, laid upon the bark of trees, especially in the crotches, and in the West are sometimes so thickly placed as to cover considerable areas two or three layers deep. When the adult mites leave the clover-fields in the fall to find hibernating quarters upon fruit-trees for the winter, they often become quite a nuisance by invading dwelling-houses which are in their path. This is more particularly the case throughout the Mississippi Valley.

Remedies.—When swarming into a house their progress may be arrested by spraying the lower part of the building, walls, etc., with pure kerosene as often as necessary. Inside the house they may be destroyed by the use of pyrethrum powder (Persian insect-powder), burning brimstone, or spraying with benzine, care being taken not to bring the latter substance near the fire.

The only practical way of protecting clover from the mite is by destroying the eggs and hibernating mites upon the fruit-trees in winter. This may be done by burning all the prunings and thoroughly spraying the trees with kerosene emulsion diluted with five parts of water, or with a mechanical mixture of twenty or twenty-five per cent kerosene and water. Such a spraying will also protect the fruit-trees from the mite, and will also destroy numerous other insects, such as the pear-leaf blister-mite, which hibernates upon the trees. Such small insects, so minute as to usually escape notice, are often responsible for a poor growth, and should be properly checked whenever known to be injurious.

The Destructive Pea-louse or "Green Dolphin" (*Nectarophora pisi* Kalt.).

Considerable injury was done to both red and scarlet clover by this pest in the spring of 1900 in Virginia, Delaware, and Maryland, and to crimson clover in Delaware in 1890. In Europe the "Green Dolphin" has been known as one of the worst pests of peas, vetches, and clovers for the past century. The aphids leave the clover about May 1st in the above States, and feed upon peas during the early summer, practically destroying the crop of late peas in 1899 and 1900. During October and November they return to the clover and pass the winter upon it.

Many predaceous and parasitic insects prey upon this pest, but it is held in check, especially on clover, chiefly by a fungous disease (*Empusa aphidis*). This disease is prevented by dry weather, and hence the pest is most injurious in dry seasons.

As yet no remedy for the pest on clover or means for prevention of injury are known.*

INJURING THE SEED.

The Clover-seed Midge (*Cecidomyia leguminicola* Lint.).

This is also a native of western New York, where its first injuries were recorded in 1878, but since then it has spread to almost every section where clover is grown, and is so serious a pest that it has become quite an art to raise a crop of clover-seed. The parent of all this trouble is a

---

* See Bull. XLIX, Del. Agr. Exp. Sta., "The Pea-louse," E. D. Sanderson; and Circular 43, 2d Ser., Div. Ent., U. S. Dept. Agr., F. H. Chittenden.

FIG. 100.—The Pea-louse (*Nectarophora pisi* Kalt.). *p*, pupa; *wg.*, winged viviparous female; *apt.*, wingless, or apterous, viviparous female and newly born young, all enlarged. (Author's illustration in Bulletin 49, Del. Coll. Agr. Exp. Sta.)

little fly, resembling a mosquito, but only about one-tenth as large; so small, in fact, that it is rarely noticed.

Life-history.—The eggs are laid among the hairy spines of the clover-head or beneath the bracts around the head. They are of a reddish color and scarcely one-tenth of an inch long. When the maggots emerge from them they

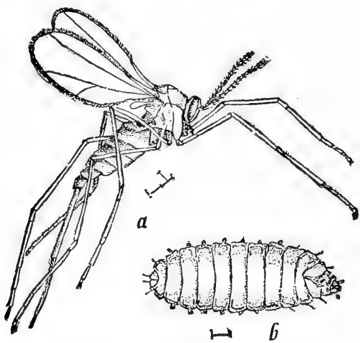

FIG. 101.—The Clover Seed-midge (*Cecidomyia leguminicola*). *a*, fly; *b*, larva, enlarged. (After Riley.)

enter the undeveloped florets, which they often prevent from flowering. In this case some of the flowers in the head will bloom, but the field as a whole does not blossom as usual. Once inside the floret the maggots feed on the developing seed. They are of a dark-red color, of a plump, oval form, and without feet. When full-grown they leave the florets and drop to the ground, into which they enter and form a little, tough, papery cocoon, just under the surface. In it they transform to the pupa, which ultimately transforms to the adult fly.

In the North two broods of the midge occur each year. The maggots of the first and principal brood become full-grown about the middle of June, and those of a smaller

one following during July and August. White and alsike clover have not been molested by the midge to any extent, but good judgment and a knowledge of the habits of the insect are needed to harvest a crop of seed from the red or mammoth.

Remedies.—Two methods are in practice for controlling this pest. The first, well adapted for dairy farms, consists in pasturing the clover until the 10th or 15th of June, and then securing a late crop of seed. The other method is to cut the clover for hay before the maggots have become full-grown and left the flowers, and then harvest a late crop of seed. Usually for red clover this will be any time during the latter part of June, and some two weeks earlier for the mammoth, as the latter will not mature a crop of seed if left later. But the exact time for cutting must depend upon the latitude and season, and to secure success will need good judgment on the part of the farmer. A good rule for red clover is to start the seed crops a few days before timothy-heads appear.

The Clover-seed Caterpillar (*Grapholitha interstinctana* Clem.).

The larva of a small moth known as the Clover-seed Caterpillar (*Grapholitha interstinctana* Clem.) has also done serious damage to the seed in Iowa and is common in clover-fields elsewhere. The greenish-white larvæ are about one-fourth of an inch long, and destroy the seed by gnawing through the florets at the base. The larvæ pupate in thin cocoons spun in the clover-head, and from them emerge the small brown moths, which lay eggs for another brood at the base of the head. Three broods occur in Iowa; in June, August, and September.

The remedies advised for the midge have also been found satisfactory for this pest.

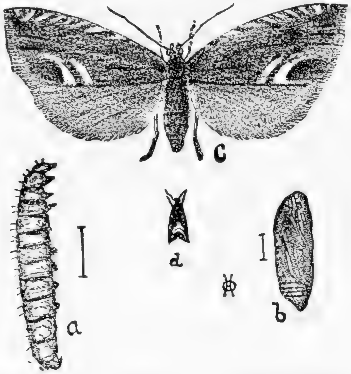

FIG. 102. — Clover Seed-caterpillar (*Grapholitha interstinctana*). *a*, caterpillar; *b*, pupa; *c*, moth, all much enlarged; *d*, moth natural size. (After Osborn.)

FIG. 103.—Clover Hay-worm (*Pyralis costalis*). 1 and 2 show larvæ suspended by threads; 3 represents the cocoon; 4, the pupa; 5 and 6, the moths; and 7, larva in a case which it has spun; all natural size. (After Riley.)

INJURING THE HAY.

The Clover-hay Worm (*Pyralis costalis* Fab.).

Even after all the above pests have been successfully combated, another insect, known as the Clover-hay Worm,

often does clover-hay considerable injury in the mow or stack. The caterpillars will usually be noticed toward the bottom of the stack if that part be searched in March or April. They are shown natural size in the illustration, and are of a dark-brown color, each segment being ringed with a band of darker brown. Hay infested by them has a moldy appearance from the numerous fine silken threads which they spin through it, often forming webs, and is so badly chewed and covered with webs as to unfit it for stock.

Life-history.—The larvæ form small silken cocoons in the cracks and crevices of the barn, from which the moths emerge early in June. As soon as the females find some clover-hay they deposit their eggs upon it, and from these the worms emerge and continue the destruction. Usually no serious injury is done except where clover-hay is kept over the second year or longer. When it is fed out each spring, before the next crop is harvested, there is no food for the young caterpillars, and they perish before the new crop comes in.

Remedies.—Thus these worms may be easily controlled by:

1. Never stacking clover-hay two successive seasons in the same place.

2. Cleaning the mow out each spring so that no old clover will be left over in the barn until the new comes.

3. Never putting new clover-hay on top of old, in stack or mow.

Though the clover-plant has numerous and serious enemies, almost all of them may be controlled by simple means, the successful use of which depends almost entirely upon a thorough understanding of the habits of the insect to be fought.

CHAPTER X.

INSECTS INJURIOUS TO COTTON.

INJURING THE LEAVES.

The Cotton-worm (*Aletia xylina* Say).

Best known of all the insect enemies of the cotton-plant is the Cotton-worm. Though the subject of numerous extensive investigations, it is such an ever-present pest that practical information concerning those habits which must be considered in successfully combating it is always pertinent. Let us commence, then, with the new year, and follow the species through the season.

Life-history.—During the winter months the adult moths hibernate in the most southern portion of the cotton belt, principally Florida and Texas, in the rank wire-grass occurring in the more thickly timbered regions. Only a few of these survive, but they are very capable ancestors, and in early March lay their eggs upon ratoon cotton where it is only an inch or two high. The eggs are laid singly, usually upon the under surface of the leaves, preferably near the top of the plant, and about five hundred are laid by each female moth. They are of a flattened convex shape, bluish green in color, and with a number of prominent ridges converging to the apex. In midsummer the eggs hatch in three or four days, but in the spring and autumn a much longer period is required.

When first emerged from the eggs the young larvæ are of a pale yellow color, but soon assume a greenish tinge, and are marked with dark spots, which become more distinct after the first molt. They then become marked as

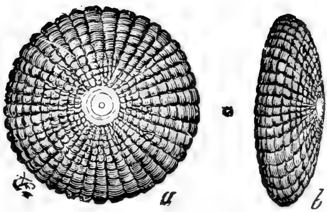

FIG. 104.—Egg of Cotton Worm-moth. *a*, top view; *b*, side view; greatly enlarged. (From Fourth Rept. U. S. Entom. Comm.)

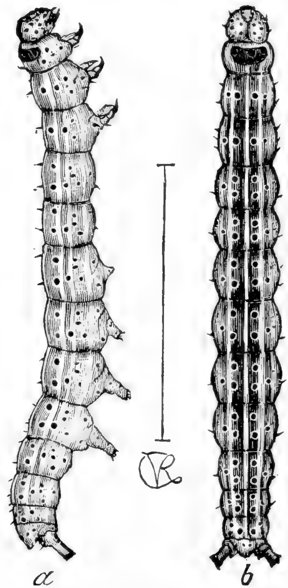

FIG. 105.—Cotton-caterpillar. *a*, from side; *b*, from above—twice natural size. (Fourth Rept. U. S. Entom. Comm.)

when adult, being more or less striped with black and are distinctly greenish. During the early season the green worms are the more common, while later the black forms predominate. The appetites of these caterpillars are only too well known to the cotton-grower. At first they are content with eating only the under surfaces of the leaves, occasionally piercing through. Then the leaves commence

to look ragged, and when these become scarce the tender twigs and buds are attacked. When excessively abundant, like the Boll-worm, the larger larvæ develop cannibalistic

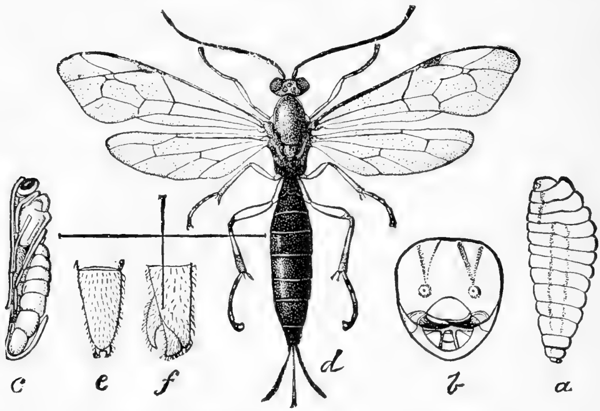

FIG. 106.—*Pimpla conquisitor*, one of the principal Parasites of the Cotton-caterpillar. *a*, larvæ, enlarged; *b*, head of same still more enlarged; *c*, pupa; *d*, adult female enlarged; *e*, *f*, end of abdomen of adult male, still more enlarged. (From Fourth Rept. U. S. Entom. Comm.)

FIG. 107.—Cotton Worm-moth. *a*, with wings expanded in flight; *b*, wings closed, at rest—natural size. (After Riley.)

tendencies and often feed upon the weaker caterpillars. It requires from one to three weeks for the larvæ to become full-grown, during which time it is necessary for them to shed their skins some five times.

The caterpillar now crawls into a folded leaf, which

sometimes is eaten away so that the pupa hangs exposed, and there spins around it a silken cocoon and transforms to the chrysalis or pupa. In this stage the insect remains dormant for from one week to a month, when the adult moth emerges.

The imago is of a dull olive-gray color with a wing-expanse of about one and one-third inches, with wings marked as shown in Fig. 107, and sometimes with a purplish lustre. Like most of its relatives of the *Noctuidæ*, or "night-flying moths," it flies only after sunset, but, unlike them, it is not confined to the nectar of flowers for food, as its mouth is peculiarly adapted to piercing the skin of ripe fruit and feeding upon its tissues. They are strong flyers, the moths of the later broods frequently flying as far north as Canada. At such times they have been known to do serious damage to peaches in Kansas, and to cantaloups in Wisconsin.

The first two broods develop rapidly, and in the extreme South and by early April the moths emerge and are carried northward by the prevailing winds. Eggs deposited by them develop into moths, which, in turn, fly further northward, and thus the worms are gradually found throughout the whole cotton belt, though with a considerable confusion between the various broods. At least seven broods occur in the far South and three at the northern limit of the species range. With this number of generations, it is readily perceived, considering the number of eggs laid by each female, how such great numbers of the caterpillars may arise by the latter part of the season, in a region where practically none remain over winter. The progeny of a single moth after four generations would amount to over 300,000,000,000 individuals, or, if placed

end to end, at the end of the third brood there would be enough to encircle the earth at the equator over four times.

Enemies.—It is thus very fortunate that the cotton-worms have many deadly enemies which commence their warfare upon them as soon as the first appearance of spring, and continue it with increasing ardor throughout

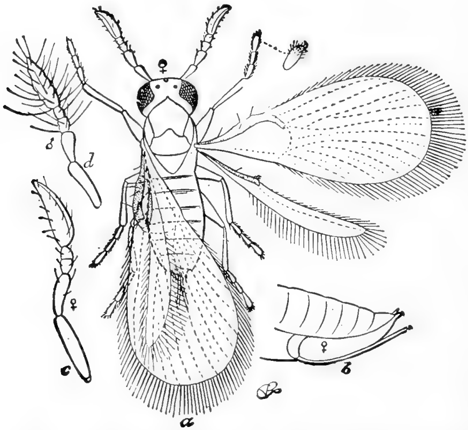

FIG. 108.—Cotton-worm Egg-parasite (*Trichogramma pretiosa*). *a*, adult female, greatly enlarged; *b*, ovipositor; *c*, female antenna; *d*, male antenna. (From Fourth Rept. U. S. Entomological Commission.)

the season. A little insect which lives inside of the eggs and is known to science as *Trichogramma pretiosa* is one of the most efficient of these. Mr. Hubbard once observed in Florida that from 75 to 90 per cent of the fourth brood of eggs and 90 per cent of the fifth were destroyed by this parasite, while only three or four eggs in a hundred escaped in the sixth brood.

One of the most useful parasites of the caterpillar was noticed to destroy nearly all of the chrysalids of the last

brood as early as 1847. The eggs of these insects are laid upon the caterpillars, and the maggots hatching from them bore into the worm and there feed upon its tissues. It transforms to a pupa as usual, but the pupa soon dies, and large numbers are thus killed. Several similar parasites prey upon the cotton-worm, among the more important of which may be mentioned *Euplectrus comstockii.* It is to be regretted that we have no way of encouraging the good work of these valuable parasites. But the common insectivorous birds which eat large numbers of the worms, especially when they are yet scarce in early spring, may and should be protected by enacting and enforcing the most stringent laws against their wanton destruction.

Remedies.—Paris green is an effectual and now widely used remedy for this pest. When the United States Entomological Commission made their extensive investigations of remedies for cotton-insects in the early 80's, they devised some very tremendous appliances for spraying this upon as many as sixteen rows at once. But such machines have not proved practical, and it was found useless to attempt spraying over four rows at once. In fact they have never been used throughout the South in other than in an experimental capacity.

Besides the general use of the dry Paris green by dusting it upon the plants as described below there have been several important factors which have so worked against the cotton-worm that the problem of keeping it in check is now considered practically solved by many authorities.

The most important of these, and a most beneficial change as regarded from other than an entomological standpoint, is the diversification and rotation of crops, now coming to be more and more widely practiced by the

progressive agriculturist of the South. This alone has been very largely responsible for checking the rapid spread of the pest.

Now that the seed has become such a valuable product of the cotton-plant, smaller varieties with many seeds and a short fibre are being grown, in contrast with the rank-growing, long-fibre sorts formerly preferred. Thus the rows are more open, the work of the worms is more readily detected, and remedies more easy of application. With these advantages in their favor, the more southern planters have come to realize the importance of destroying the early broods, and by doing so have been able to keep them in a state of comparative subjection.

For many years the most commonly used and, experience has shown, effective remedy is the use of the dry Paris green. It is usually dusted upon two rows of plants, from bags fastened at the ends of a pole, and carried by a man on horseback, who can thus poison from 15 to 20 acres per day. These sacks are about ten inches long by four inches in diameter, open the whole length of one side and firmly sewed at the ends. Eight-ounce Osnaburg is the best cloth for the purpose. A strip of oak or strong wood about one and one-half by two inches, and five feet long, has a one-inch hole bored through it at five inches from each end, and to this the sack is tacked, fastening one of the edges of the opening to each of the narrow sides of the pole. The sacks are filled through the holes in the pole. When freshly filled a slight jarring will shake out a sufficient amount of the poison, but when nearly empty the pole should be frequently and sharply struck with a short stick, or spaces in the rows will be missed. The poison has been found most effective without the admix-

ture of flour. If that be added, lighter cloth should be used for the sacks.

The remedy for the cotton-worm is simple and effective. It simply needs careful watching, especially upon the part of the southernmost planters, and prompt work immediately upon its appearance.

Cutworms.

For very few plants could a list of their insect-pests be made without mentioning the destructive cutworms (see page 214 to 217), and cotton is no exception. Their characteristic manner of cutting off the young plants at the surface of the soil is so familiar to every planter and trucker that no discussion of their life-history and habits is here necessary. The best method for their destruction is by distributing through the field bunches of clover or grass poisoned with Paris green. This may be best done by spraying a patch of grass or clover with the poison, then cutting it, loading it on a wagon, and scattering bunches over the field with a fork. For best results such traps should be spread over the field just as the plants are appearing above ground, or even a day or two before; some care is necessary in so doing this that it will not result in injuring the young leaves.

Grasshoppers.

A much similar treatment will prove effectual for grasshoppers, which frequently do considerable damage to the foliage. Twenty-five pounds of bran, one pound of white arsenic, mixed dry and then slightly moistened with water and cheap molasses, will form an excellent "mash" for their destruction, by placing a teaspoonful at the base of

each plant. Some fourteen different kinds of grasshoppers have been known to injure cotton, but of these the American Acridium (*Schistocerca americana*) and the Differential Locust (see page 69) are the most injurious.

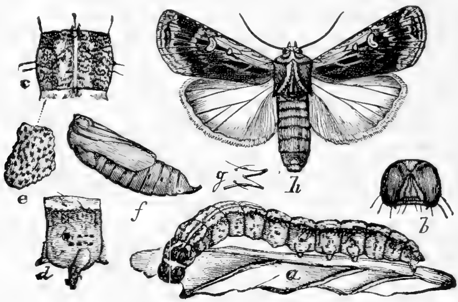

FIG. 109. — Granulated Cut-worm (*Agrotis annexa*). *a*, larva; *f*, pupa; *h*, adult—natural size. (After Howard, U. S Dept. Agr.)

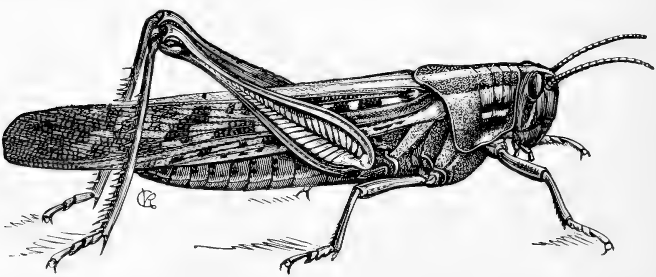

FIG. 110.—The American Acridium (*Schistocerca americana* Scud.). (After Riley.)

Caterpillars.

Many species of Lepidopterous larvæ occasionally defoliate the cotton-plant, among the most common being the Bag-worm (*Thyridopteryx ephemeræformis*), Fall Armyworm (*Laphygma frugiperda*) (see page 84), Garden Webworm (*Loxostege similalis*) (see page 260), and the Leafroller (*Cacœcia rosaceana*). Any of these may be destroyed

by applying Paris green in a spray or dust, as for the cotton-worms.

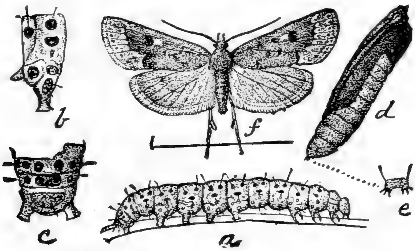

FIG. 111.—Garden Web-worm (*Loxostege similalis*). *a*, larva, enlarged; *b*, side view of abdominal segment of same; *c*, dorsal view of anal segment; *d*, pupa; *f*, moth, enlarged. (After Riley, U. S. Dept. Agr.)

Plant-lice (*Aphidæ*).

The plant-louse which is most frequently found injuring the leaves of the cotton-plant is the same as the melon-louse (*Aphis gossypii*). As upon melons, its worst injury is done while the plants are yet young, and in such cases the best practice is to destroy the infested plants and replant in their place. A spray of kerosene emulsion and water or similar irritant will kill them, and sometimes may be used to advantage; but owing to the rapid and hardy growth of the plant, and the fact that large numbers of them are consumed by their insect enemies, plant-lice are seldom of any great importance.

INJURING THE STALK.

If it escapes the cutworms, the stalk of the plant will not be troubled further with insects, as long as it is in a healthy condition. Occasionally plant-bugs puncture the new growth, but such damage is rarely of importance. One of the boring-beetles, known as *Ataxia crypta* (Fig. 112), has been supposed to injure the stalk by boring in

it, but investigation shows that its eggs are laid only upon stalks which have already been damaged in some other manner.

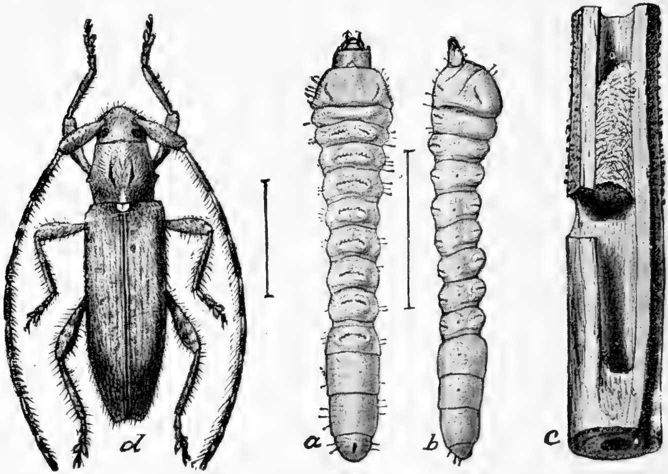

Fig. 112.—Cotton Stalk borer (*Ataxia crypta*). *a*, larva from above; *b*, larva from side; *c*, tunneled cotton-stalk showing exit-hole; *d*, adult beetle—all enlarged except *c*. (After Howard, U. S. Dept. Agr.)

INJURING THE BOLL.

Sharpshooters.

Bolls are frequently damaged by leaf-hoppers, known to science as *Homalodisca coagulata*, which injury is termed "Sharpshooter work" by the planters. Usually they do not make their appearance till after the first of June. Before that they prefer the foliage of poplar and other shade trees near the cotton-field. Where the injuries are of annual occurrence it would be well to ascertain the trees upon which the insects are feeding, early in the season, and give them and neighboring undergrowth a

thorough spraying with strong kerosene emulsion during May.

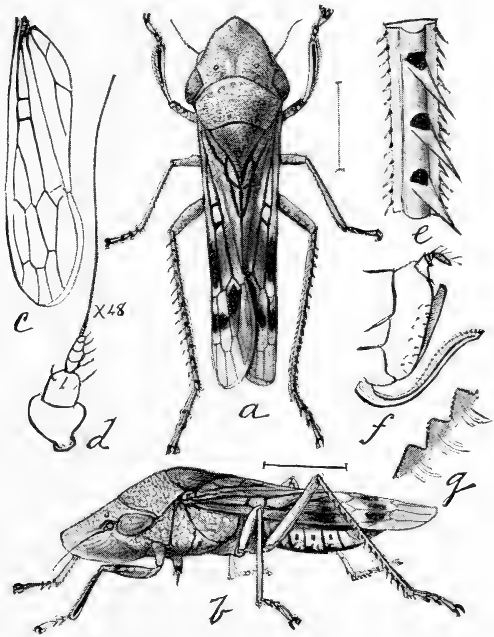

FIG. 113.—*Homalodisca coagulata.* *a*, adult female seen from above; *b*, same, side view. (After Howard, U. S. Dept. Agr.)

"Cotton-stainer."

The Red Bug or Cotton-stainer (*Dysdercus suturellus*) once did considerable damage to the bolls in Florida, Georgia, and neighboring parts of Alabama and South Carolina, but of late years has devoted most of its attention to oranges. Early in the season they stunted the bolls and made them abortive by sucking the sap; but the most serious damage was done later, when they entered the open bolls, "puncturing the seed and damaging the

fibre" by their yellowish excrement. This indelible stain greatly depreciated the market value of the fibre, and was a vexing loss. Though never of commerical importance, it was found by experiments that a rich orange dye could be made from these insects, which could be easily

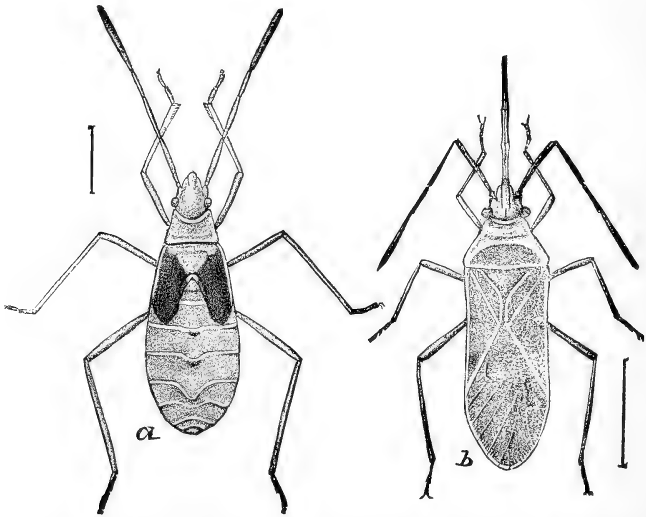

FIG. 114.—The Red Bug or Cotton-stainer (*Dysdercus suturellus*) enlarged. *a*, nymph; *b*, adult. (From "Insect Life.")

fixed upon silks and woolens by an alum mordant. In winter these insects congregate in heaps of cotton-seeds, and by using these as traps the insects may be killed with hot water.

Several other insects attack the bolls, but never very extensively. Among them is a weevil (*Aræcerus fasciculatus*) often mistaken for the Mexican Boll-weevil and which closely resembles that insect. It is a "cosmopolitan

FIG. 115.—Transformation of Cotton Boll-worm. 1, egg on under side of cotton-leaf; 2, larva one third grown boring into square; 3, entrance-hole of young larva in square with excremental pellets at edge of hole; 4, nearly full-grown larva just issued from boll; 5, full-grown larva on leaf-stem; 6, pupa shown in centre of underground earthen cell; cell shown in longitudinal section; 7 adult moth, light variety; 8, adult moth with dark fore wings; 9, adult moth in resting position, wings slightly elevated. (After Howard, U. S. Dept. Agr.)

[*To face page* 201.]

insect living in the pods of various plants, among others in those of the coffee-plant in Brazil, but is never shown to attack healthy plants."

Various leaf-eating caterpillars often gnaw the bolls, but will be destroyed by poisoning the foliage as previously described.

If the Paris green be applied for the Cotton-worm, and the general methods advised for the control of the Boll-worm and Mexican Boll-weevil be followed out, little fear need be had of these minor insects, though a knowledge of the best remedies for them is always desirable in case of their apppearing in unusual numbers.

The Cotton Boll-worm (*Heliothis armiger* Hubn.).

The Cotton Boll-worm is one of the pests most widely dreaded by the cotton-grower, and differs from the Cotton-worm in that it is found in other parts of the world as well as America, and is not restricted to a single plant-food.

The Moth.—The adult moth is about the same size as the Cotton-worm moth, but has a larger body and a greater variety of markings. When at rest the fore wings of the Cotton Boll-worm moth are slightly parted, while in the Cotton-worm moth they are closed. The Boll-worm moth varies much in color; both wings are bordered with dark bands, the wing-veins are black, and there are other black spots upon the fore wings. It may generally be seen about dark, and hides itself during the day in cow-peas and clover, sipping the honey from the blossoms of these and other honey-secreting plants, but does not, like the Cotton-worm moth, feed upon fruit.

Life-history.—It deposits its yellowish-white eggs upon all parts of the cotton-plant, but prefers the silk and

tassels of corn. If hatched on the cotton-plant, the worms attack the young buds or bolls, rapidly destroying them.

The young worms resemble the cotton-worms, and walk like the familiar measuring-worms, but are darker in color. With age the worms exhibit great variety in appearance, from light green to dark brown or rose, and may be either striped or spotted or perfectly plain.

The life of the insect from egg to adult averages about thirty-eight days, and there are usually five generations each year. The worms of the first brood, as a rule, appear about the first of May, and feed almost entirely upon the young leaves and buds of the corn; the second brood, appearing in early June, eat the tassels and forming ears of corn; the third brood, in July, attack the hardening ears. The fourth and fifth broods, appearing successively in August and September, appreciate the cotton as food, the corn having become too hard. About the middle of October the worms of the last brood descend into the earth to pupate, which state lasts from one to four weeks.

Food.—The worm is known by various names according to the plant upon which it feeds, as, for instance, the Cotton Boll-worm, the Corn Ear-worm (see page 151), and the Tomato Fruit-worm. It is also found upon peas, beans, tobacco, pumpkins, squash, and many flowering plants. A strange but mitigating characteristic of this pest is its tendency to feed upon its kind, especially if large numbers are crowded together, thus materially reducing its own numbers.

Remedies.—Poisoning the young worms by spraying with arsenic was a method formerly used, but as it proved only partially successful, and as another and better method has been discovered, it is now comparatively little used.

The more effective method of keeping the insect in control is the result of practical experience, and consists in the wise use of what are known as trap crops. Let five acres be planted with cotton and corn alternately with every seventy-five or one hundred acres of cotton, or in the same relative proportion for smaller areas. Of the five acres, for every twenty-five rows of cotton let five rows be left vacant. In these five vacant rows plant, as early as possible, one row of an early-maturing sweet corn, planted sparsely, as only a small number of plants are desired. During the silking period let frequent search be made for the yellowish-white eggs, and when fresh eggs can no longer be found let the silk ends of the corn covered with eggs and young worms be cut off and destroyed by burning or feeding to stock; or better still, to insure perfect safety, let the entire plant be destroyed. Let three other rows be planted with dent corn so as to bring the silking period about the first of July. The larger number of eggs which will be laid on these three rows should be allowed to mature for the preservation of the natural enemies which parasitize the eggs and young worms. The crowded condition of the worms in these rows will result in a large amount of cannibalism, so that only a small number will reach maturity, recompense for which will be found in the parasites. But to entrap these individuals, let the fifth row be planted so as to reach the silking period about August first, and let this row be cut and destroyed as soon as the laying of eggs upon it ceases. It has been found that the corn produced from the second planting will generally pay for the expense of cultivation and the sacrifice of the five rows of corn. In many cases, if the other two be properly cared for, the third planting will not be

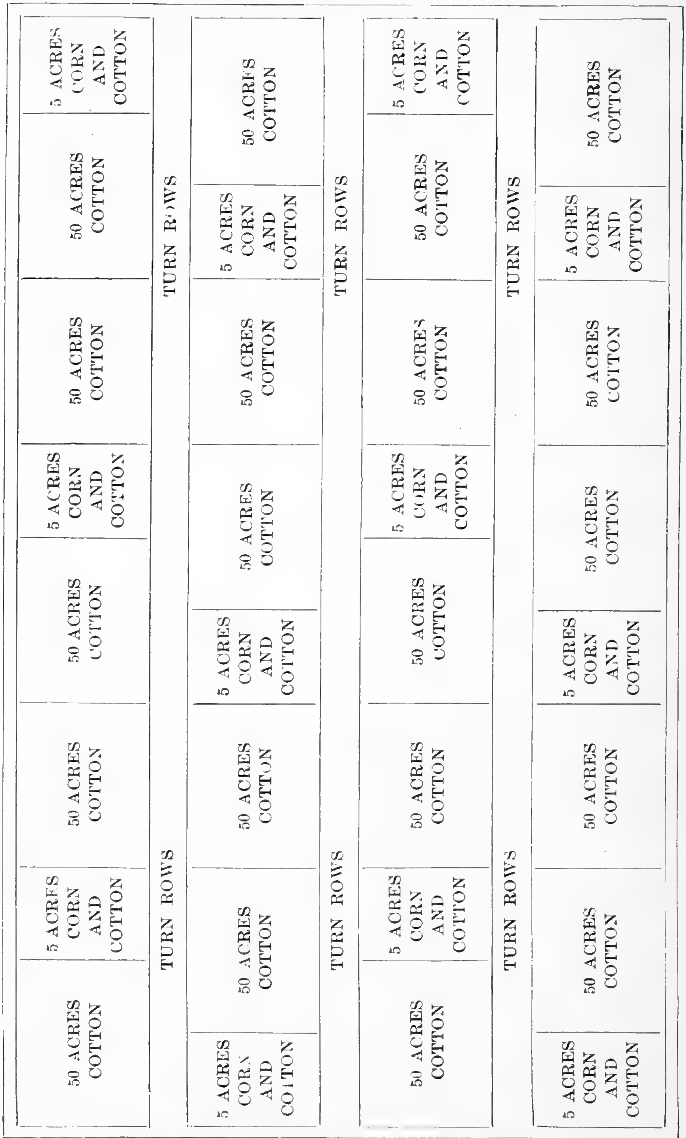

FIG. 117.—Diagram of Cotton-field showing location of trap-corn. (After Howard, U. S. Dept. Agr.)

necessary. The entire success of this latter method of combating the Cotton Boll-worm depends upon careful observations and judicious planting, based upon a correct knowledge of the life and habits of the insect.

The Mexican Cotton Boll-weevil (*Anthonomus grandis* Boh.).

Several of the worst insect pests of the South have immigrated thither from Mexico. About 1890 some small beetles came across the Rio Grande near Brownsville, Texas, which so rapidly multiplied in numbers during the following seasons that in certain sections the crop was entirely ruined. As early as 1862 these insects caused the growers at Monclova, Mexico, to abandon the culture of cotton, and when they again planted it, about 1893, the beetles promptly appeared and destroyed the entire crop.

At the close of 1894, an agent of the United States Department of Agriculture (Mr. C. H. Townsend), sent especially to investigate their ravages, reported that between one-fifth and one-sixth of the cotton-growing section of Texas was infested, there being a loss of from 25 to 90 per cent of the crop. This meant 15 per cent of the whole crop of the State, 3 per cent of that of the United States, and in round numbers, 2 per cent of the world's product, with a cash value of over $8,000,000. The outlook was certainly alarming.

Fortunately its worst ravages have been confined to the southern portion of Texas. This is largely because the damage done and the spread of the weevils are worst where the top crop is most valued, which is the condition in southern Texas. Its ultimate spread to other regions,

however, seems inevitable; and a knowledge of its habits and methods for its control are therefore not untimely.

The parent of all the mischief is a small, grayish beetle, hardly one-fourth of an inch in length, while the perpetrators of the worst injury are the little, fleshy grubs or larvæ, which live and feed within the squares and bolls.

Life-history.—Until late in December, or as long as any

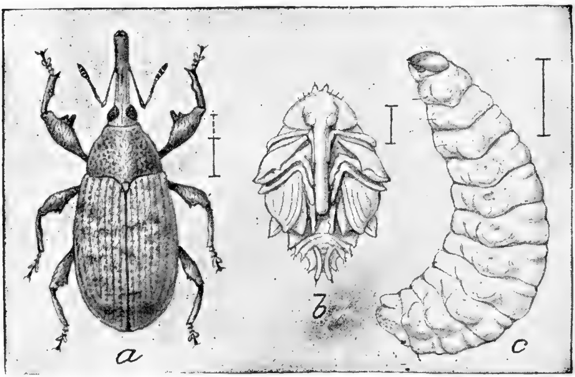

FIG. 116.—The Cotton Boll-weevil (*Anthonomus grandis* Boh.). *a*, adult beetle; *b*, pupa; *c*, larva—enlarged. (From "Insect Life.")

part of the plants are green, the beetles may be found upon them. During the winter they hide in the rubbish on the field or among the weeds surrounding it, and there hibernate until the sunshine of early spring brings them forth for another season of depredation. As soon as the buds have formed on the volunteer plants the beetles are upon them and lay their eggs in the early squares. Almost invariably, the work of a larva hatching from one of these eggs causes the "square" infested to drop to the ground, where the larva becomes full-grown, transforms to a pupa, and comes forth as a beetle in about four weeks in all,

FIG. 118.—The Cotton Boll-weevil. *a*, newly hatched larva, in square; *b*, nearly full-grown larva in situ; *c*, pupa in young boll picked from ground. (After Howard, U. S. Dept. Agr.)

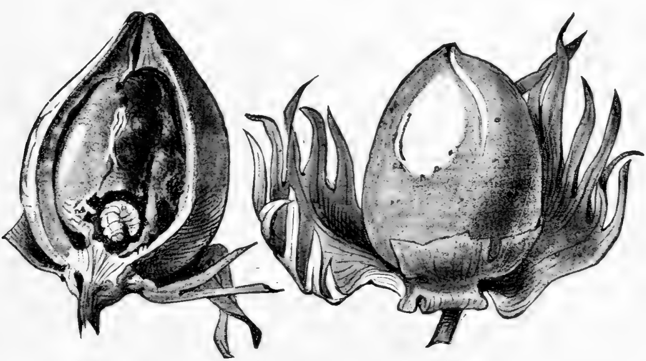

FIG. 119.—Mature Boll cut open, at left showing full-grown larva; one at right showing feeding-punctures and oviposition marks. (After Howard, U. S. Dept. Agr.)

Thus one or two generations develop on the volunteer cotton. By the time the planted cotton is high enough to form squares the weevils have become quite numerous, and, as a result, a large portion of the squares soon drop.

FIG. 120. — Late Fall Boll, showing how beetles hide between boll and involucre. (After Howard, U. S. Dept. Agr.)

The first indication of the presence of the pest is by the absence of the blooms. The squares also drop in much more than ordinary numbers and though this might be due to other causes, if they are cut open the presence of the weevil will soon become apparent. Infested bolls are characteristically discolored and punctured. "Late in the season the weevils themselves will be found between the involucre and the boll, or, in their absence, the feeding marks and the yellow, granular excrement which collects at the base of the boll are excellent indications."

The bolls are attacked in the same manner as the squares, but do not drop. The weevils also do considerable injury by eating into the bolls, making ugly punctures with their stout little snouts. Although a single larva will ruin a boll, as many as a dozen are often found in one. Thus the destruction goes on, and inasmuch as it takes each female several days to complete her egg-laying, by July the different generations or broods have become so intermingled that it is impossible to make a distinction. Not until the frosts of late fall do the weevils cease to breed and feed. Then they go into winter quarters, and almost all of the larvæ are killed by the frosts.

Remedies.—The following suggestions as to the best methods for the control of this pest have been largely gleaned from a forthcoming report of Mr. W. D. Hunter,* a special agent of the Division of Entomology, U. S. Dept. Agriculture, who has made an extended investigation of the matter during the season of 1901 (Mar.—Dec.) and which comprises the previously expressed opinions of Dr. Howard † and his assistants, Messrs. Marlatt and Schwarz, as to the importance of better cultural methods for its control.

Inasmuch as the pest is notably worst where the top crop is gathered late into the fall, the most obvious, and as the experience and investigations of the past five years have shown, the best and most practical means for its control is in the entire abandonment of the top crop and the destruction of the plants by October, or earlier. The value of the late fall top crop seems to be very much overestimated, as very often it hardly pays for the picking and in the last twenty years only four or five top crops of any value have been secured. As the beetles hibernate over winter in the bolls and among the old plants, the immediate destruction of the plants in the fall will destroy most of the weevils. The plants may be cut with a stalk-chopper or thrown out with a plow, and should then be burned. After this the plowing of infested land to the depth of 6 or 8 inches is advisable. In this way all the larvæ and pupæ in the cotton at the time are destroyed, as well as many of the weevils; the adult beetles are buried by the deep plowing and will never again reach the surface; the removal of the stalks and rubbish prevents their hiberna-

* To appear in Yearbook, U. S. Dept. Agr., 1901.

† "The Mexican Cotton Boll-weevil," Circular 14, 2d Ser., Div. Ent., U. S. Dept. Agr., L. O. Howard.

tion in the field; the growth of volunteer cotton has been largely prevented; and the field is left clean of old stalks, facilitating thorough cultivation the following year. "Fields treated in this way have given a practical demonstration of the usefulness of this method." (Howard, l.c.) Where the fields are free from grass, cattle may be turned in to graze on the green tips of the cotton and will thus consume and destroy many of the beetles. Inasmuch as a comparatively small number of the beetles which go into hibernation pass through the winter alive, it is of the utmost importance that their numbers be reduced as much as possible in the fall.

Those beetles which do winter successfully appear in the spring rather late and as a consequence early cotton is but little injured. The importance of cultivating early varieties of which the bolls develop before the pest becomes abundant is therefore apparent. Furthermore, early cotton brings by far the best prices and is usually not subject to serious injury by other insect pests. Plants grown from northern seed seem to mature earlier than those grown in southern Texas. The selection and breeding of early maturing varieties is therefore of considerable importance in this connection. Growers in the heart of the badly infested regions of Texas have found that by merely growing early varieties they can secure a yield as good as the average throughout the country.

Injury being worst on low, moist ground, it would seem best to reserve such land for other crops.

"In connection with the system of fall treatment of the cotton, constant and thorough cultivation of the growing crop is of considerable value, and is also what should be done to insure a good yield. With a cross-bar to brush

the plants, many of the blossoms and squares containing weevils will be jarred to the ground and buried, together with those already on the ground, in moist soil, and a large percentage of the material will rot before the contained insects have developed." (Howard, l.c.)

The advantage of controlling this and other insect pests by such cultural methods is at once apparent when the small margin of profit in the growing of cotton and the economic conditions incident to large areas of land being farmed by tenants are considered. Such cultural methods involve no outlay of cash, which makes any other method prohibitive to most tenants. There seems, also, to be a real danger of an overproduction of the cotton crop, and a diversification and rotation of crops would do much to solve the question of how to combat this and other insects of the cotton-plant. It seems certain that the control of this pest merely requires a better system of agricultural practice, as is the case with the Hessian Fly (see page 110) and many of our worst insects.

On a small scale much may be done by planting the rows farther apart than usual. Where the rows of cotton are grown close together the soil between them is shaded from the sun and remains moist, furnishing the best condition for the development of the larvæ in the fallen squares. Where rows are farther apart the soil is heated by the sun to such an extent as to kill large numbers of the larvæ. That the rows are usually placed too close for the proper growth of the crop has been demonstrated by several agricultural experiment stations. It has been shown that in spite of the much smaller number of plants, one-fourth more cotton can be secured from rows five feet apart than from those three feet apart.

Upon small areas the application of Paris green by spraying the volunteer plants as they appear in the spring, and two or three times during the next two weeks, will greatly check the increase of the pest. The young tips are the parts which should be most thoroughly sprayed, and as the number of volunteer plants will not be very great, such spraying will not require much time. The solution used should be as strong as one pound of Paris green to fifty gallons of water, as it does not matter if the volunteer plants are killed by it. Volunteer plants appearing in deserted cotton-fields or corn-fields should be destroyed as far as possible.

Picking up the fallen squares and burning them is urged by Prof. Mally* as one of the best means of fighting it. He records that one cotton-grower "who had fourteen acres of old land in cotton, picked up his squares faithfully and made seven bales. His neighbor, who is conceded by all to be the better farmer, had an adjoining field of twenty-five acres of cotton, but did not gather and burn his squares, made two bales." He states that eleven negroes picked up the squares on ninety acres between 9 A.M. and 6.30 P.M., at a cost of $8.00, or less than 10 cents per acre. The squares should be picked up every ten days or two weeks. This method is only practicable, however, upon small areas.

But few insect parasites seem to infest the larvæ and but little aid can be hoped from them. Quail and turkeys have, however, been reported as eating large quantites of the weevils and being most beneficial.

---

* "The Mexican Cotton Boll-weevil," Farmers' Bulletin No. 130, U. S. Dept. Agr., F. W. Mally.

The Mexican Cotton Boll-weevil is only one of the many insect pests which are becoming permanent factors in agriculture and which are forcing the American farmer to adopt better agricultural methods, which, if generally practiced, would result not only in their control, but cause less drain upon the soil through a better rotation of crops, and better crops as a result of more constant and thorough cultivation.

CHAPTER XI.

INSECTS INJURIOUS TO TOBACCO.

It would hardly be supposed that a plant like tobacco, which when dried is used as an insecticide, would be troubled with many insect enemies, and experience has shown this to be very largely a fact, as only three or four insects are recognized as what might be termed "standard pests" of tobacco throughout the country, though an equal number, whose injuries have not been especially noticed hitherto, have been coming into prominence in various sections in recent years; yet the few insects which do attack tobacco, if left to themselves, are entirely capable of doing a vast amount of damage; for that which would be considered but a slight injury to other plants means a considerable loss in the sale of a tobacco-crop with imperfect leaves.

INJURING THE YOUNG PLANTS.

Cutworms.

To begin with, as soon as the plants are set out they are attacked by those old foes of the farmer, with which he has to contend in the growing of almost every truck and garden crop, the Cutworms. The cutting of the stems of the young plants by these worms often necessitates replanting, sometimes a second time. This injury is especially

severe where a crop of grass or clover has been turned under as a soil crop in the spring and there furnishes a good supply of food for the cutworms till the tobacco is set out. Not only is this replanting expensive and tedious itself, but it makes the crop mature unevenly and thus entails unnecessary expense in handling.

Description and Life-history.—Under the general term "cutworms" we commonly designate the larvæ of several species of moths, which are very similar in general appearance and habits. Both the moths and larvæ are readily

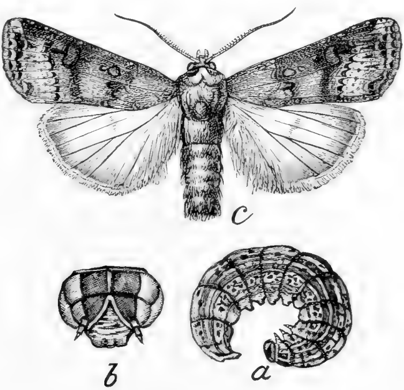

Fig. 121.—Greasy Cutworm (*Agrotis ypsilon*), one of the Tobacco Cutworms. *a*, larva; *b*, head of same; *c*, adult—natural size. (After Howard, U. S. Dept. Agr.)

distinguished by one familiar with them. Though the life-histories of the different species vary more or less, still they are so much alike that they may be readily described as a class. Of those attacking tobacco, the Greasy Cutworm (*Agrotis ypsilon*) and Granulated Cutworm (*Agrotis annexa*) are among the most common. The adults of cutworms are moths with dark fore wings, variously marked, which are folded over the back when at rest, and

with lighter hind wings, as shown in the illustration—natural size. Like the cutworms, they feed at night, sipping the nectar from flowers, and the family to which they belong has therefore been named the *Noctuidæ*. As a rule there is but a single brood of worms in a season, though a second one is not unusual. The female moths lay the eggs on stones, leaves, trees, etc., almost any place where the ground is well covered with vegetation, so that the young worms can readily find food. They are usually deposited during midsummer and the larvæ become partially grown before winter, when they hollow out an oval cell in the earth, curl up, and hibernate till spring, seemingly unaffected by freezing. The next spring, after their long fast, the young vegetation is eaten with surprising voracity. When full-grown a cutworm is of a dull brown, gray, or greenish hue, generally marked with longitudinal stripes, oblique dashes and dots, and is from one and one-fourth to two inches long. The head and segment back of it are reddish brown and horny. There are eight pairs of legs; the first three jointed and tapering, the last five short and stout. As soon as full-grown the worm enters the earth to pupate, and from the pupa transforms to the adult moth from late July to early August. Though besides the larvæ all the other stages are known to sometimes hibernate over winter, nevertheless the life-cycle is usually so that the worms are hungry for the young spring plants, and though numerous during the whole season, it is during the spring that their devastation is worst and most noticed.

Remedies.—From the habits above outlined it may be seen that much can be done to exterminate these pests by a thorough cultivation of the land to be planted, during

the spring, thus depriving the worms of any food during that time. The most successful method yet found for destroying the worms is in the use of a poisoned bran mash. This is composed of forty parts of wheat-bran, two quarts of cheap molasses, and one pound of Paris green, with enough water to thoroughly moisten the whole. The bran and Paris green should be thoroughly stirred together while dry and the molasses diluted with water, and then poured on and stirred in. The land where the tobacco is to be set out should be prepared several days before. Then drop about a tablespoonful of the mash near each hill, doing this from three to five days before the plants are set out, and as near evening as possible. Chickens, etc., should be kept out of the field for several days. The cutworms are attracted by the smell of the molasses and seem to relish the mash, coming out of the ground and making a liberal meal upon it—a meal which almost always proves fatal. This remedy is at once simple and inexpensive and has been found most satisfactory by growers who have used it. Any other arsenite could be used instead of Paris green, though the amount used would vary according to the strength of the poison.

The Tobacco Stalk-worm (*Crambus caliginosellus*). (See page 130.)

Prof. W. G. Johnson* has found this species, also known as the Corn-root Web-worm, to be a serious pest to growing tobacco-plants in southern Maryland, where it seems to have been a tobacco-pest for at least fifteen years, and it has also been noted in Delaware.

The Injury.—The injury to tobacco is described by

* Bull. 20, n. s., U. S. Div. Ent., U. S. Dept. Agr., pp. 99–101, 1899.

Prof. Johnson as follows: "The uninjured tobacco had a leaf-spread of from ten to twelve inches. A few rods beyond, where the soil was not so gravelly and better, we found the larvæ had literally destroyed the first and second plantings, and were at work upon the third, damaging it severely, although the ground had been replanted before the last planting. Here and there was a young plant just beginning to wilt, and invariably we found the larva at work either in the stalk or at the base of the plant just below the surface of the ground. So far as I could ascertain the attack is always at the surface or just below. In many instances the larvæ had hollowed out the stalks from the base of the roots to the branches of the first leaves. Many plants were gnawed irregularly around the stalk below the surface, and some, in fact, were completely cut off at the surface, the insect always working from below. In the great majority of cases the larvæ were found in a small mass of web near the plant, and sometimes within it. In one plant, less than six inches high, we found four larvæ within the stalk, but as a rule only a single one was present."

Prof. Johnson concluded "(1) that it is most likely to occur over local areas in tobacco following timothy or grass; (2) that the character of the soil has little or nothing to do with its ravages; (3) that the attack upon corn is also a frequent occurrence in the same section, especially when following grass or timothy."

Remedies.—He recommended "(1) that growers of tobacco avoid planting upon grass or timothy sod; (2) that where grass land is plowed down it would be well to put it in wheat, following with clover, before tobacco. If desirable, corn could follow the grass and the land could

be seeded in crimson clover at the last working. This would serve a twofold object by revealing the exact location of larvæ in the area under cultivation by their attack upon corn, when they could be destroyed largely by frequent harrowing and rolling, and by affording a most excellent soil crop to turn down the following spring, which would be a decided advantage to the tobacco; that if it is found necessary to have tobacco following grass, it should be broken in the spring as early as possible, and frequently rolled and harrowed, at the same time delaying the setting of the plants as long as possible in order to destroy and starve the larvæ within the ground."

INJURING THE STEM.

The Spined Tobacco-bug (*Euschistus variolarius*).

Prof. H. Garman has found a small bug, which he has termed the Spined Tobacco-bug, doing more or less injury to plants in Kentucky, and as this insect is widely distributed throughout the country, it probably does more or less damage elsewhere, though never a serious pest. Concerning its work, he says:* "Occasional plants in tobacco-fields are at times observed to have become suddenly wilted, the leaves hanging limp, much as if the stalk had been severed. After a time they recover again, and, beyond a temporary check on their growth, appear to have suffered but little injury. If such plants are searched carefully while still wilted, a flat, brown bug with each side of the body produced into an angle, or sharp spine, will be found upon the stalk along the base of the leaves. It is very shy and keeps out of sight, hence any brisk movement on the injured plants is likely to cause it to drop to the ground

* Bulletin No. 66, Ky. Agr. Exp. Sta., p. 33.

and conceal itself." These insects are true bugs, sucking their food through a beak, which is bent under the body between the legs when not in use. They are about half an inch long, of a drab color above and greenish or yellowish below. Usually only one bug is found on a plant, so that the best way to prevent the injury is to pick them from the plants, and keep down such weeds as thistles and mulleins, upon which such insects feed, in the adjoining fields.

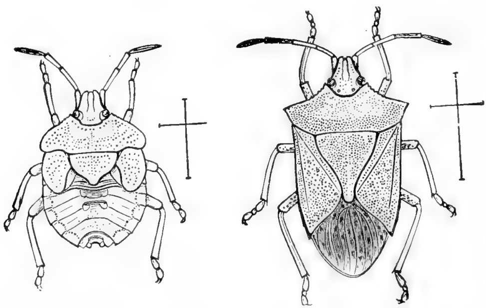

FIG. 122.—*Euschistus variolarius.* Nymph at left; adult at right—enlarged. (After Howard, U. S. Dept. Agr.)

INJURING THE "BUD."

Bud-worms (*Heliothis armiger* and *rhexiæ*).

Before the leaves of the tobacco have unrolled they are subject to the attacks of two larvæ, known as "Bud-worms." Though the adult moths of these two insects are very different in appearance, the larvæ are much alike.

The Corn-worm, Cotton Boll-worm, or Tomato-worm (*Heliothis armiger*), as it is called in different sections, is well known to all growers of these crops and needs no extended description. Corn is the favorite food of these worms, on which they first riddle the leaves

and then bore into the forming ear, but as the corn hardens they leave it for cotton, tobacco, etc. When an abundant food-supply of corn or cotton is not found by them during the early part of the season, they turn to tobacco. On tobacco the moths deposit their eggs in the buds, and when the larvæ emerge from them a few days later, they do very serious injury by eating the unrolled leaves, boring into the bud, which may be entirely consumed by a large worm. As the leaves grow, these holes become larger, and the leaves are thus ruined for the best grade of tobacco. The later broods seem to prefer the unripened seed-capsules, and eating into them they devour the immature seed. From two weeks to a month are required for a larva to become full-grown, when it descends into the ground and constructs a loose silken cocoon just below the surface. In this it transforms to the pupa, or chrysalis, and remains dormant for from one to four weeks, when the adult moth emerges. The moths are about the same size and belong to the same family—*Noctuidæ*—as those of the Cutworms. The color varies from dull ochre-yellow to dull olive-green; both wings are bordered with dark bands; the wing-veins are black, and there are several other dark markings on the fore wings. Throughout the cotton-belt there are four or five broods during a season, but fewer farther north, the number depending upon the latitude and season.

Another species of this genus (*Heliothis rhexiæ*) has been found to be more common in Kentucky, and, as it is not known to attack any other cultivated plant, is known as the "Tobacco Bud-worm." Both species are usually found where tobacco is raised and in Florida the Corn-worm (*H. armiger*) is the most injurious. They are alike

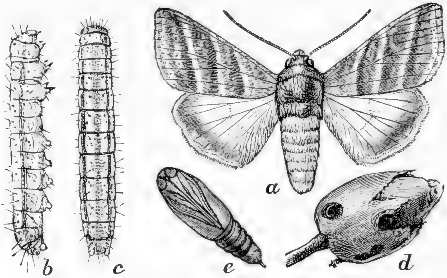

FIG. 123.—The True Bud-worm (*Heliothis rhexiæ*). *a*, adult moth; *b*, full-grown larva, from side; *c*, same, from above; *d*, seed-pod bored into by larva; *e*, pupa—natural size. (After Howard, U. S. Dept. Agr.)

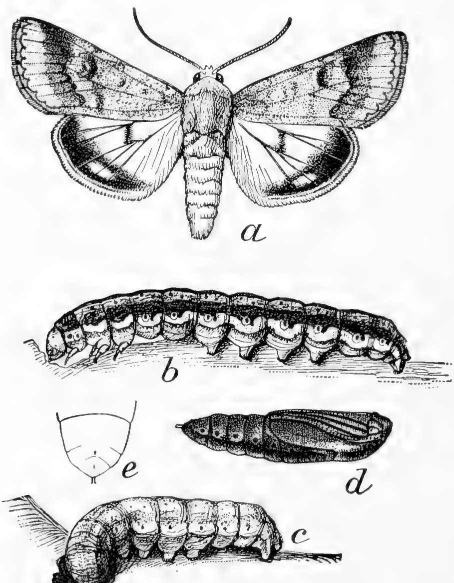

FIG. 124.—False Bud-worm or Cotton Boll-worm (*Heliothis armiger*). *a*, adult moth; *b*, dark full-grown larva; *c*, light-colored full-grown larva; *d*, pupa—natural size. (After Howard, U. S. Dept. Agr.)

in their habits and depredations upon the tobacco-plant. The original food-plant of *rhexia* is probably one of our common weeds such as the horse-nettle, which should therefore be kept cut down along the edges of the tobacco-

FIG. 125.—Larva of Bud-worm (*Heliothis armiger.*) Showing work on seed-capsules of tobacco-plant. (After Quaintance.)

fields and in those adjoining. The moths of this species are quite different from those of *armiger*, the fore wings being of a sea-green color, crossed by three white bands, and the hind wings white with a dark margin. Only one or two broods occur during a season.

Remedies.—Poisoned corn-meal has been found to be a

satisfactory remedy for both species. Into a quart of finely ground corn-meal, a half teaspoonful of Paris green is thoroughly mixed by stirring, and sprinkled on the buds from a can perforated like a pepper-can. This should be applied frequently, especially after heavy rains. Large buds should be opened and a pinch of the poison placed within. When spraying with Paris green is practiced against the Horn-worm, it will also be of service against the Bud-worms. When the Corn-worms are the more common species, it would seem that the use of strips of corn used as a catch crop, as used in protecting cotton from the same insect, would be of value. By planting a row of corn here and there around the tobacco-field, the moths will preferably deposit their eggs upon it, and it can then be cut and a large part of the injury to tobacco thus prevented.

INJURING THE LEAVES.

The Suck-fly (*Dicyphus minimus* Uhl. Mss.).

As tobacco has become more generally grown in Florida, a small bug known to the planters as the "Suck-fly" has become increasingly injurious, until it is now considered as the worst insect pest of tobacco in many parts of that State. So far as known it has not been recorded as injurious elsewhere, though it has been noticed in Florida plantations for at least ten years.

Life-history.—The adult is a small bug about one-eighth of an inch long, with rather long, yellowish-green legs. The upper surface of the insect is black, except the front margin and a central stripe of yellow on the first segment back of the head, while the under side is greenish. The wings are folded over the back when at rest. The "flies"

become numerous enough to be injurious during the first two weeks in June, usually being first noticed in one corner of a field, from which they rapidly spread over the whole. The eggs are deposited singly, in the tissues of the leaf, mainly on the smaller veinlets, and hatch in about four days. The young nymphs at once attack the foliage, and after molting about four times transform to adults about eleven days later. The full-grown nymphs are of the same general appearance as the adults, except that the wings are still undeveloped and form small wing-pads, but are of a greenish color. As it requires but a fortnight for the development of a brood, these insects multiply very rapidly and in a few weeks become so numerous as to seriously damage the foliage, hundreds of them being found on a single leaf. The injury is done by their inserting their small beaks into the tissue of the leaf and sucking the juices, causing the leaf to become yellowish or wilted, and cracking older leaves so that they become ragged. "Experienced growers say that the leaves badly infested with the Suck-fly are very difficult, if not impossible, to properly cure." The weather plays an important part in the control of this pest. "According to an observant grower, 'an important factor in bringing about their disappearance has been the absence of rain during the latter part of August and early September. The sticky exudation from the glandular hairs of the tobacco-plant causes many of these insects to become stuck to the leaf and in this way a great many are killed. Frequent showers keep this washed off to a considerable extent, and thus favor the insects.'" (Quaintance.) A veritable fly-trap!

Remedies.—In experimenting with insecticides for this pest, Prof. Quaintance has found, curiously enough, that

the only ones fatal to it are preparations of its own food—tobacco. A solution of one part of "Nikoteen" to sixty of water is a very satisfactory remedy. This insecticide

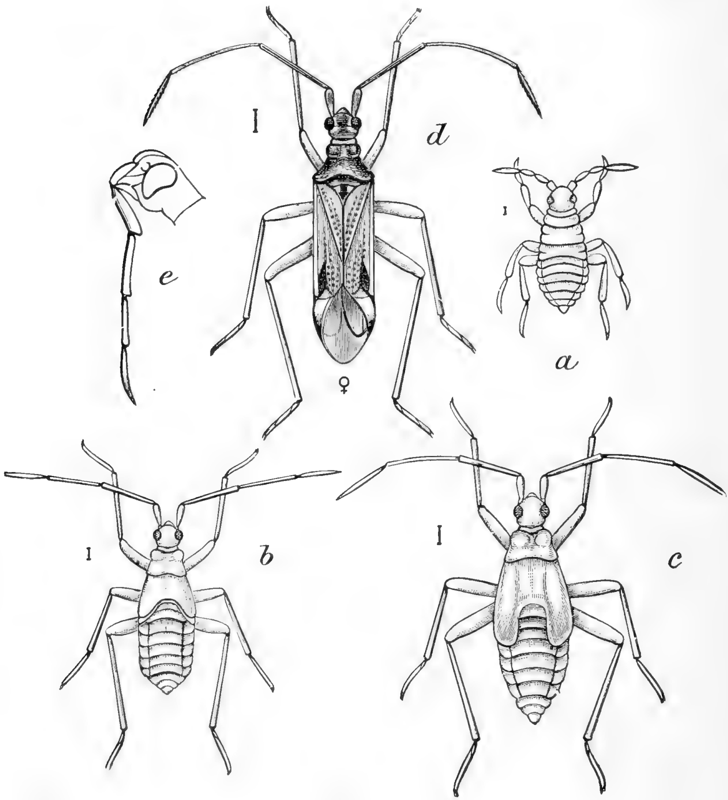

FIG. 126.—The Suck-fly (*Dicyphus minimus*). *a*, newly hatched; *b*, second stage; *c*, nymph; *d*, adult; *e*, head and beak from side—enlarged. (After Howard, U. S. Dept. Agr.)

is a concentrated solution of nicotine and is manufactured by the Scabcura Dip Co., Union Stock Yards, Chicago, Ill. It should be sprayed over the plants, using a bent-

necked nozzle which will throw a fine mist upon both the upper and under surfaces of the leaves, as most of the young are on the lower surfaces. Where refuse tobacco is at hand a good decoction can be made by boiling it at the rate of one pound to a gallon of water for an hour, then draining off, and straining well before spraying. This will not keep for more than two or three days before fermenting, but where it can be used at once is less expensive than "Nikoteen." The spraying should be done early in the day, when the adult bugs are sluggish and do not fly readily. Keep a sharp watch for the "flies" early in June, and by attacking them upon their first appearance they may be kept from spreading and be destroyed before they have done much injury and much more readily than when more numerous.

MINING THE LEAF.

The Tobacco Leaf-miner (*Gelechia solanella* Boisd.).

The larva of a small moth has become quite injurious in parts of North Carolina and Florida by mining the inside of the leaf, and is thus known as the Tobacco Leaf-miner. This insect occurs in other parts of the country, but has become injurious only in the States named and in recent years. The injury is done by the larvæ eating out irregular patches of the tissue in the leaves, leaving only the upper and lower surfaces, the lower leaves being infested the worst. The leaves are rendered unfit for wrappers, splitting and tearing very easily on account of these blotches. A larva does not confine its work to one place, but makes several mines, and a single larva may thus destroy the value of a leaf for wrapping purposes. This migratory habit is of considerable importance, as in leaving the old and in

making new mines the larvæ must necessarily eat a certain amount of the surface of the leaf, and can thus be killed by an arsenical spray. The life-history of the insect is not completely known, but as only about twenty days are required for all its transformations, several broods probably occur during a season. The original food-plant of this pest has been found to be the common horse- or bull-nettle (*Solanum carolinense*), which fact further emphasizes the

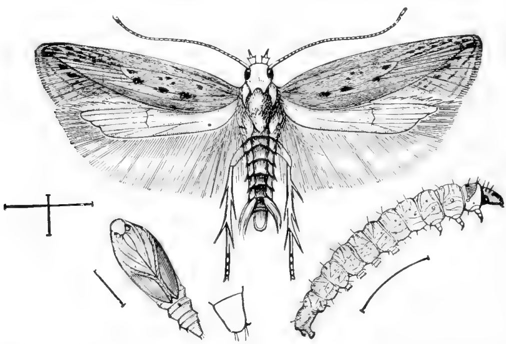

FIG. 127.—Tobacco Split-worm. Adult moth above; larva below at right; pupa below at left, with side view of enlarged anal segment—all enlarged. (After Howard, U. S. Dept. Agr.)

caution already given, to keep all weeds carefully cut down around the tobacco-field, especially those nearly related to tobacco botanically. Many planters destroy the larvæ by simply crushing them with the hand, and this can be done quite rapidly, and if done before the mines become numerous should be sufficient to check the injury. Where spraying with Paris green is practiced against the Horn-worm it should be sufficient to destroy most of the miners, as, if the leaf is thoroughly coated with poison, they would get a fatal dose in starting a new mine.

The Tobacco Flea-beetle (*Epitrix parvula* Fab.).

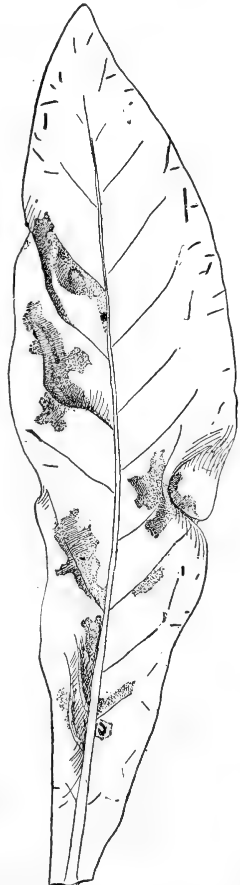

Fig. 128. — Work of Split-worm—reduced. (After Howard, U. S. Dept. Agr.)

The Tobacco Flea-beetle is one of the insects which has become increasingly injurious upon tobacco-leaves in recent years. So far as recorded its injuries have been noticed only in the northern part of the tobacco-belt, viz., Kentucky, Ohio, West Virginia, Maryland, and Connecticut. The leaves are damaged by having small holes eaten in the upper or under surfaces, or sometimes clear through them. When badly eaten the leaves appear as if peppered with shot, the injury being especially severe to young plants. The adult beetles which do this injury are very small, hardly more than one-twentieth of an inch long, of a light brown color, with a dark band across the wing-covers. A few of them could do but little injury, but they soon increase until they swarm over the leaves and injure them badly. The life-history of this species has not been studied until recently and is not yet well known. Mr. F. H. Chittenden has ascertained that the larvæ feed habitually upon the roots of the common Nightshade and Jamestown weed. These are undoubtedly the usual food

of the larvæ, as of the nearly allied Potato Flea-beetles (*E. cucumeris* and *fuscula*), but when the beetles become more numerous the larvæ sometimes feed upon tobacco-roots, doing them more or less damage, but generally not to a noticeable extent. The breeding of this insect upon these common weeds further emphasizes the caution

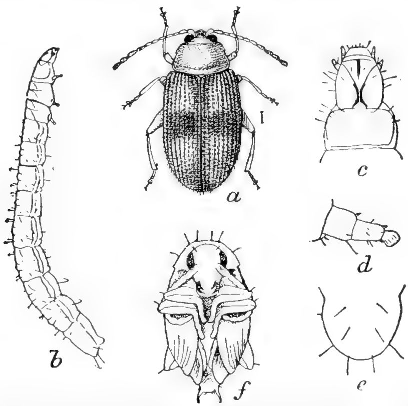

FIG. 129.—Tobacco Flea-beetle (*Epitrix parvula*). *a*, adult beetle; *b*, larva, lateral view; *c*, head of larva; *d*, posterior leg of same; *e*, anal segment, dorsal view; *f*, pupa—*a*, *b*, *f*, enlarged about fifteen times; *c*, *d*, *e*, more enlarged. (After Chittenden, U. S. Dept. Agr.)

already given in previous chapters to see that they are kept cut down. Spraying with Paris green as advised for the Horn-worm will also keep this insect in check.

Grasshoppers.

Grasshoppers have often been known to eat tobacco-leaves quite badly. Of these, our most common species, the Red-legged Locust (*Melanoplus femur-rubrum*), has been recorded most often. If the plants have been sprayed with Paris green, it will usually be sufficient to prevent serious injury by grasshoppers. If they are very numerous,

however, a bran mash such as advised for use against Cutworms will be found attractive to them. A tablespoonful placed at the base of each plant will be sufficient to prove fatal to the locusts.

The Horn-worm or Tobacco-worm (*Protoparce celeus, P. carolina*).

Of all the insects feeding upon tobacco, this one is the most injurious and consequently most generally known. In many sections on account of its damage to that plant it is also known as the Tomato-worm. It may be well to first state, however, that two species of insects are ordinarily included under this popular name. The Northern Tobacco-worm is the more common form in many of the more northern parts of the tobacco-belt, especially in Connecticut, though it is generally found wherever tobacco is extensively grown in the United States. The Southern Tobacco-worm (*P.*

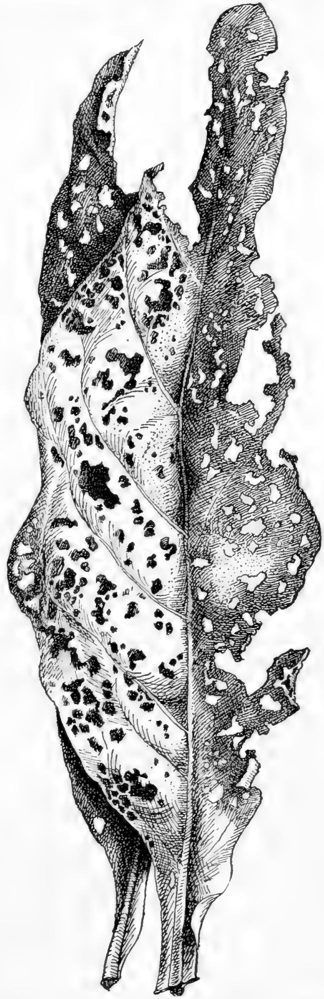

FIG. 130.—Tobacco-leaves damaged by *Epitrix parvula.* (After Howard, U. S. Dept. Agr.)

carolina) also occurs throughout all the tobacco-producing States and is usually much the more common form in

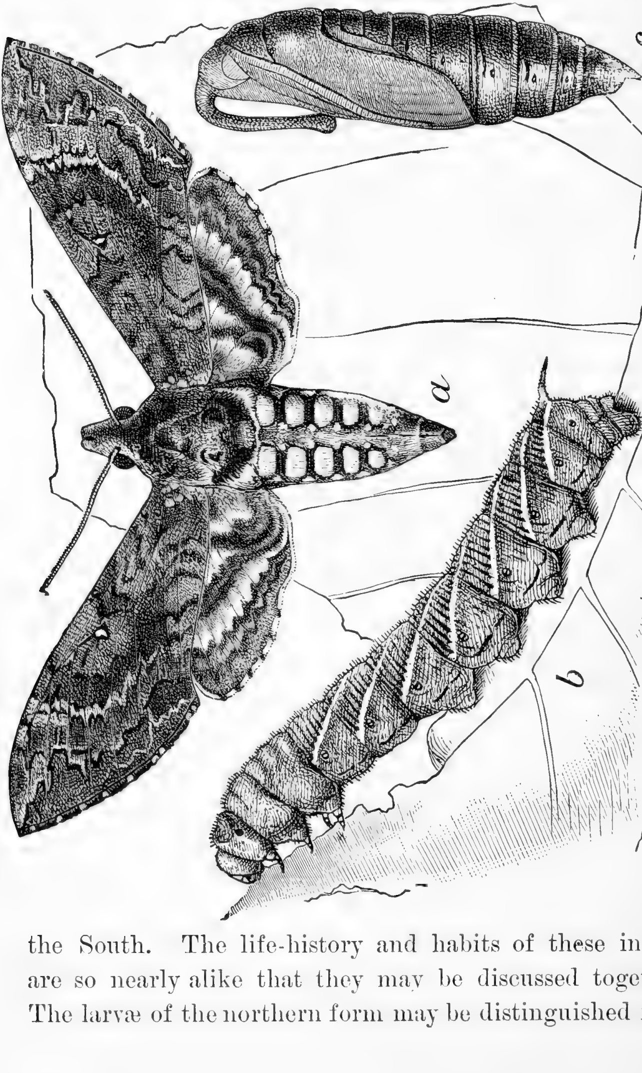

FIG. 131.—Southern Tobacco-worm (*Protoparce carolina*). *a*, adult moth; *b* full-grown larva; *c*, pupa—natural size. (After Howard, U. S. Dept. Agr.)

the South. The life-history and habits of these insects are so nearly alike that they may be discussed together. The larvæ of the northern form may be distinguished from

the southern by the V-shaped markings along the sides, those of the latter being simple oblique bands. The differences between the moths are well shown in the illustrations.

Life-history. — The pupæ from which these moths emerge in May and June remain in the ground over winter. The females then deposit their eggs, singly, upon

FIG. 132.—Southern Worm killed by Fungus. (After Garman.)

the lower surfaces of the tobacco-leaves, which hatch out in three days. The way in which the young worms now attack the tobacco foliage is well known to every grower. During their growth, which occupies about three weeks, the worms molt some five times. They then transform to pupæ, in which state they remain about three weeks, when the adults emerge and the same life-cycle—occupying about six weeks—is repeated. The first brood of worms usually does not do very serious damage, the one in July being that against which the planter's attack should be directed. Usually three broods occur in a season, sometimes but two

in the North and four in the South. Occasionally the worms are overlooked in cutting the tobacco and do con-

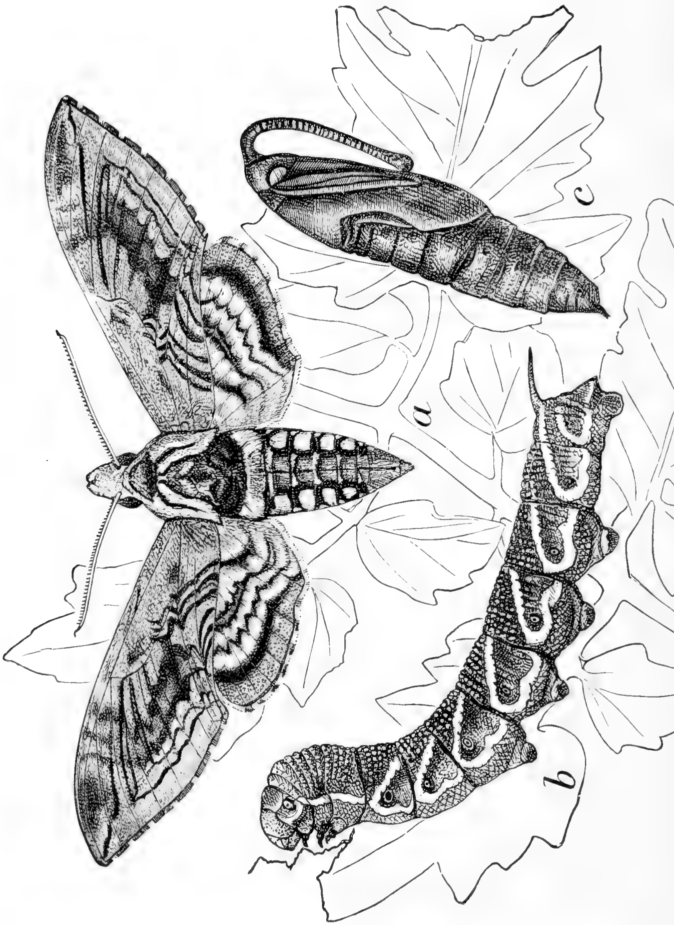

Fig. 133.—Northern Tobacco-worm, or "Horn worm" (*Protoparce celeus*). *a*, adult moth; *b*, full-grown larva; *c*, pupa—natural size. (After Howard, U. S. Dept. Agr.)

siderable injury to it even after it has become partially dry in the barn, though there is little excuse for this.

Remedies.—The oldest and most common method of

controlling this pest is that of hand-picking. This is, however, both tiresome and expensive. I am informed that in southern Maryland this task is willingly done by large flocks of turkeys, which are kept largely for that purpose and fed on little else during the time the worms are most numerous.

In many parts of Kentucky a spray of Paris green has been used against the Tobacco-worm. Against this there has been more or less of a popular prejudice on account of possible poisoning. Such a prejudice having also existed against the use of this well-known arsenite upon apples for the Codling-moth and on numerous other crops, and with no deleterious results, it seems safe to assume that such a prejudice is unfounded. Nevertheless Prof. H. A. Garman has made a careful test of such spraying, and plants sprayed were analyzed by Dr. A. M. Peters, chemist of the Ky. Agr. Exp. Station, who found that the amount of arsenic left on leaves sprayed three times with a solution of one pound of Paris green to 160 gallons of water would not be sufficient to be injurious to the consumer. In the numerous tests made, one-third of a grain of arsenic per pound of tobacco was the most ever obtained, and would hardly be injurious. Prof. Garman (Bulletin No. 63, Ky. Agr. Exp. Station) also made thorough tests as to the efficiency of this method of controlling the worm, which he found to be entirely satisfactory. Usually it will not be necessary to spray over three times, if applied at the proper time. The time of these applications will vary for different latitudes and seasons, but should be made as soon as the young of each brood make their appearance. In general this will be early in July, early August, and middle or late August. One pound of Paris green to 160 gallons

of water is strong enough if properly applied, and in no case should it be used stronger than one pound to 125 gallons. The best way of applying the mixture is by means of a knapsack-pump, and both surfaces of the leaves should be sprayed.

Florida growers have used the arsenite of lead to some extent, dusting it on the plants dry, by means of a bellows or powder-gun, such as is manufactured by Leggett Bros., 301 Pearl St., New York. It is a white powder, more insoluble than Paris green, but it will not burn the foliage as readily. It is also more adhesive when thus applied, remaining on the foliage for eight or ten days.

A method for killing the adult moths has been satisfactorily practiced for many years. It consists in poisoning the flowers of the Jamestown weed (*Datura stramonium*) with a sweetened cobalt solution. The flowers are placed around the fields in the evening, being set upright in holes of horizontal slats, or supported by sticks. The cobalt solution is then introduced into them by means of a quill. It is composed of—cobalt, one ounce; molasses, one-fourth of a pint; water, one pint. In their search for flowers the moths will be attracted by the odor of the molasses and the cobalt of the solution will poison them, and thus prevent the females from laying some two hundred eggs toward another brood.

Enemies.—There are also several insects which tend to keep this pest in check by parasitizing it, and about which many growers do not seem to be well informed. Worms covered with what seem to be small white eggs are always common. They are not eggs, however, but the cocoons of a small hymenopterous insect whose larvæ feed upon the worm internally and thus ultimately kill it before it

becomes full-grown or transforms to the pupa. Such parasitized worms should never be destroyed, as the parasites are of more value than the damage the worm might do (Fig. 134).

FIG. 134. — Southern Tobacco-worm with Cocoons of Parasite. (After Garman.)

INJURING STORED TOBACCO.

The Cigarette-beetle (*Lasioderma serricorne* Fab.).

Even after the crop has been cured and has been packed away, sometimes for years, it is subject to the ravages of the larvæ and adults of a small beetle, called the Cigarette-beetle. This pest also infests numerous other stored products, household goods, upholstery, etc. The beetle is but one-sixteenth of an inch long, of a brownish color, with the prothorax bent under in front so that the head is obscured as under a hood. The pupal stage is passed in a delicate cocoon; the whole life of the insect being spent in the infested goods.

Remedies.—Infested tobacco should be opened up, if packed tightly, placed in tight boxes, or a tight room, and exposed to the fumes of carbon bisulfide, using it the same as for grain-insects. This liquid is very volatile, giving off a gas heavier than air and fatal to all insect life. The quantity used would depend upon the tightness of the

enclosure and the way in which the tobacco is packed. One ounce to every fifty cubic feet of enclosed space will doubtless be ample. This should be placed in shallow vessels on top of the tobacco and allowed to remain for twenty-four hours. No injury will be done the tobacco,

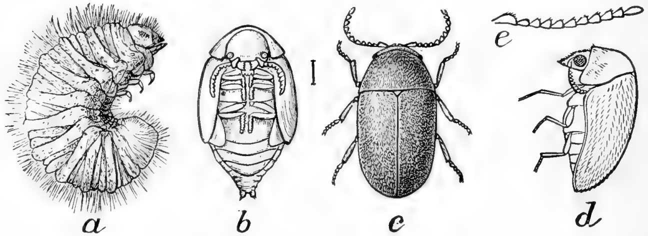

FIG. 135.—The Cigarette-beetle. *a*, larva; *b*, pupa; *c*, adult; *d*, side view of adult; *e*, antenna—all greatly enlarged; *e*, still more enlarged. (After Chittenden, U. S. Dept. Agr.)

but care should be taken in the use of this chemical that no light, cigar, etc., be brought near it, as it is highly combustible and such carelessness might cause a serious conflagration.

Hydrocyanic acid gas has recently been used very successfully by Prof. W. G. Johnson in ridding some large tobacco warehouses of this pest.

CHAPTER XII.

INSECTS INJURIOUS TO THE POTATO.

INJURING THE TUBERS.

Potato-scab and Insects.

THAT certain forms of what is commonly termed "potato-scab" are due to the work of insects has frequently been shown. In 1895 Prof. A. D. Hopkins, of the West Virginia Agr. Experiment Station, reported some very careful original investigations upon two species of gnats, *Epidapus scabies* Hopk. and *Sciara* sp., the larvæ of which had been conclusively shown to cause a scab upon the tubers by boring into them. He found that "they breed in and are especially common in barnyard-manure," that "excessive moisture in the soil has been observed to be the most favorable condition for their development," and that "soaking the seed-potatoes in a solution of corrosive sublimate previous to planting" will kill all the eggs and young larvæ, as it will also destroy the spores of the potato-scab fungus.

Prof. A. H. Garman has also recorded the injuries of several species of millipedes, or "thousand-legged worms," *Cambala annulata* and *Parajulus impressus*, as causing a scab by gnawing into the surface of the tubers. Though both of these observations are unquestionably true, they

have not been verified in other parts of the country, and it is improbable that any large portion of potato-scab is due to these insects. Potato-scab is a fungous disease, which, as already noted, may be destroyed by soaking the seed-potatoes in a solution of corrosive sublimate.

Some interesting observations have been published by Messrs. Stewart and Sirrine, of the New York station, in which they attribute the peculiar marking of the skin known as "pimply" potatoes to the larva of the small black cucumber flea-beetle, *Epitrix cucumeris* Harris, which, as a beetle, does so much injury to the leaves. Without doubt this instance is a parallel to those already mentioned concerning insects producing potato-scab. Undoubtedly the larvæ of this beetle may have been found producing "pimply" potatoes, but several other entomologists and the writer have carefully examined hundreds of tubers in fields fairly alive with the beetles, and at all seasons of the year, but all in vain as far as discovering any flea-beetle larvæ is concerned.

The truth of the matter is that the natural food-plants of these larvæ are some of our commonest weeds. Similar instances are observed in the larvæ of the Sweet-potato Flea-beetle (*Chætocnema confinis* Gr.), Bean Leaf-beetle (*Cerotoma trifurcata* Foerst), Tobacco Flea-beetle (*Epitrix parvula*), and others which are all occasionally found on the roots of the respective food-plants of the beetles, but which habitually feed in the larval stage upon the roots of such weeds as the horse-nettle, Jamestown weed, *Desmodium*, and various *Solonaceæ*. In fact, the only insects which are habitually injurious to the tubers are white grubs and wireworms, both of which are only too familiar to every farmer. So far as known, the only remedy for these

will be rapid rotation of crops, until the infested land has become clear of them.

INJURING THE STALK.

The Potato Stalk-borer (*Trichobaris trinotata* Say.).

In some sections this insect has rivaled the famous Colorado Potato-bug in the damage it has inflicted upon potato-vines. It was recorded in Iowa as badly damaging the crop there in 1890, and was found by Dr. Riley in Missouri as early as 1869. The beetles were first noted in

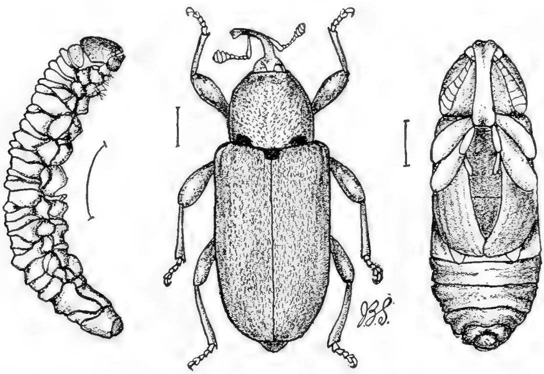

FIG. 136.—Potato Stalk-borer (*Trichobaris trinotata*). Larva, pupa and adult. (After J. B. Smith.)

New Jersey in 1895, and during the last few years have been doing serious injury to the fields of northwestern Maryland.

Life-history.—The grubs, which bore into the stalk of the vines, are the larvæ of some small ashen-gray beetles which appear early in spring and into June. These beetles are about one-fourth of an inch long, with a long, black beak or snout, and are marked at the base of the wing-covers by three black spots which give the insect its specific

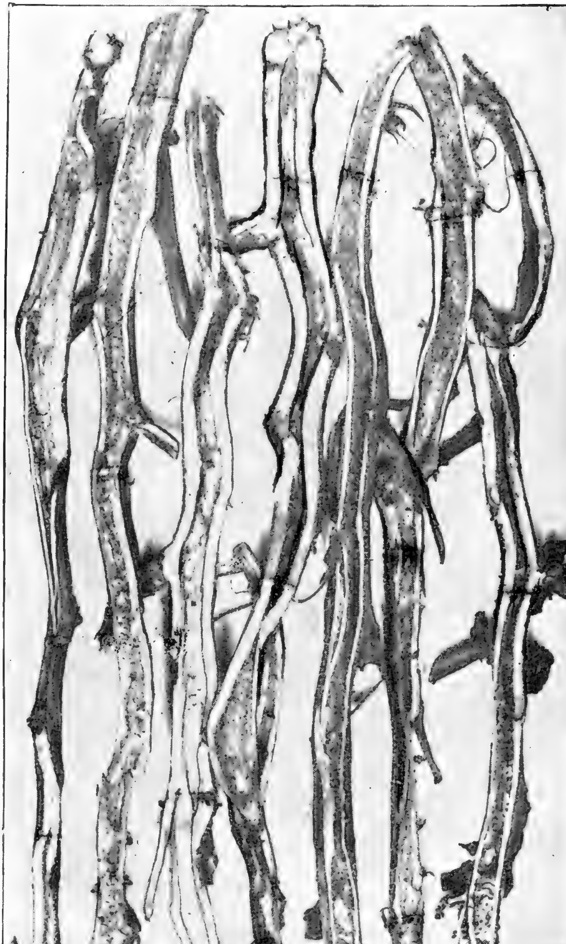

FIG. 137.—Work of Potato Stalk-borer in Potato-vines. (After J. B. Smith.)

name, *trinotata*. Each beetle punctures a small hole in the base of a stem by means of its beak, hollows out a small cavity, and there lays a single small, oval, whitish egg. From these eggs some small, white grubs with brown heads hatch in a few days and commence to bore into the stalk. These grubs keep eating, either in the main stalk or branches, from August 1st to September 1st, when they have become full-grown. At this time the grubs are about one-half an inch long, of a dirty white or yellowish color, with a yellowish-brown, horny head, and without legs. About the middle of August, as a general rule, the grub constructs a small, oval cocoon of chips and fibres in the stalk of the vine near the surface of the soil, and there transforms to the pupa. During late August and September the mature beetles shed the pupal skins, in which they have remained dormant for the last few weeks, but remain in the vines during the winter, and do not come forth till the following spring.

Remedies.—On account of its internal feeding habits no poison can be successfully used against this pest, and the only remedy, but a good one, is to rake up the vines and burn them as soon as the potatoes have been dug. As this insect also feeds upon the Jamestown weed, horse-nettle, and other weeds of the Nightshade family, or *Solonaceæ*, they should be kept cut down very closely. When the grubs are noticed in the plants, a good allowance of fertilizer will do much to quicken growth and thus enable them to mature a crop.

INJURING THE LEAVES.

Colorado Potato-beetle (*Leptinotarsa 10-lineata* Say.). First and foremost among the enemies of the potato-

grower stands the Colorado Potato-beetle—the insect which in the early seventies, on account of our ignorance of it, was made an entomological bugbear. But "there's no great loss without some small gain," and we may be thankful that the invasion of this beetle also brought about the use of Paris green, an insecticide which has since saved thousands upon thousands of dollars to the American farmer. Thus, with an effectual remedy which

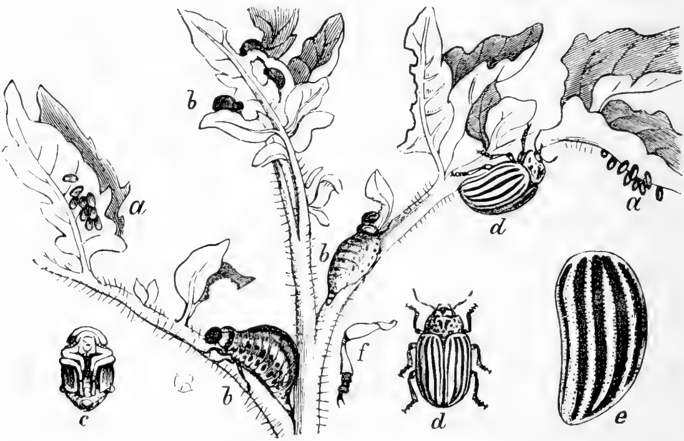

FIG. 138.—The Colorado Potato-beetle (*Leptinotarsa decemlineata* Say.). *a*, eggs; *b*, larvæ; *c*, pupa; *d*, beetle; *e*, elytra or wing-cover of beetle; *f*, leg of beetle. (After Riley.)

is now used where this pest occurs as regularly as potatoes are planted, "familiarity" has "bred contempt," and to-day we have but little fear of its attack.

History.—As is probably known to most of the older generation who watched its spread eastward, the Colorado Potato-beetle, as its name indicates, was a native of the Rocky Mountain region, and until about 1855 was satisfied with feeding upon various common weeds of the same

genus as the potato-plant, principally *Solanum datura* Dunal, and closely allied genera. But with the settlement of this country and the introduction of the Irish potato, these bugs also began to take advantage of the fruits of civilization and transferred their feeding-grounds from the roadside to the potato-patch, and rapidly spread eastward from one to another, as well as being imported in the shipping of the potatoes.

Thus, in 1859 they had reached a point one hundred miles west of Omaha, Nebraska; five years later crossed the Mississippi into Illinois; and advanced steadily eastward till recorded among the Atlantic States in 1874. Though slow to be introduced into some few sections of the country, it is safe to assert that this pest may to-day be found almost wherever the potato is grown in the United States or southern Canada.

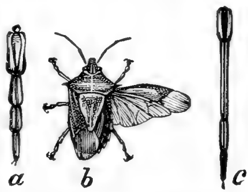

FIG. 139.—*a*, beak of predaceous bug; *c*, beak of plant-feeding bug. (After Riley.)

Life-history. — During October the beetles enter the earth and there hibernate till the warm sunshine of April or May brings them forth. As soon as the young plants appear, the female beetles deposit their yellow eggs upon the under side of the leaves near the tips, each female laying from six hundred to one thousand eggs during the course of a month. Meanwhile the beetles have done considerable damage by eating the young and tender plants. In about a week, there hatch a horde of very small but very hungry larvæ, which fairly gorge themselves with potato-foliage and increase in size with astonishing rapidity. In four or five weeks, after having eaten an

amount of food out of all proportion to their size, the larvæ have become full-grown, and enter the earth, where they form smooth, oval cells, and transform to the pupæ. In a week or two the adult beetles emerge from the pupal skins and after feeding for a couple of weeks, deposit eggs for another brood. The life-history of this brood is the same, except that the time required for it is less than for the first, and following it comes the third brood, the beetles of which hibernate over winter as already described. The time required for the development of a brood is exceedingly variable, and owing to the length of time required for laying the eggs, and the fact that some larvæ become full-grown much more quickly than others, all stages of the insect may be found during the summer months.

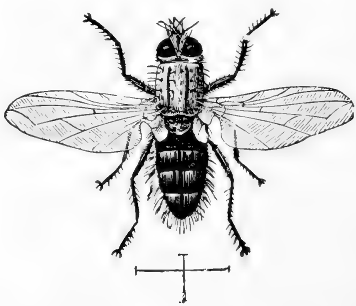

FIG. 140.—Tachinid Parasite of Colorado Potato-beetle (*Lydella doryphoræ* Ril.). (After Riley.)

Natural Enemies.—One of the chief agencies to prevent the excessive multiplication of this pest is the weather. Thus, Professor Otto Lugger records that in Minnesota, late in the fall of 1894, the beetles were lured from their winter quarters by a few warm days, and most of them subsequently perished from hunger or frost. In addition

to this during the late summer of 1894 there was an excessive drouth, so that but few of the third brood matured. Thus in 1895 there were very few of the insects to be seen.

Among the birds, the common crow, red-breasted Gros-

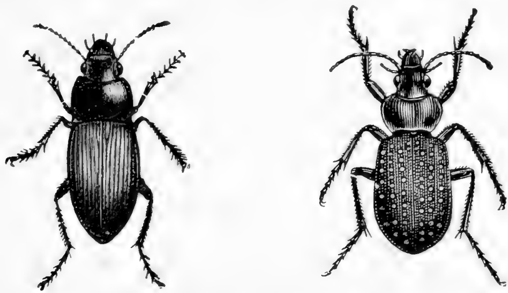

FIG. 141.—Murky Ground-beetle (*Harpalus caliginosus*) and Fiery Ground-beetle (*Calosoma calidum*). (After Riley.)

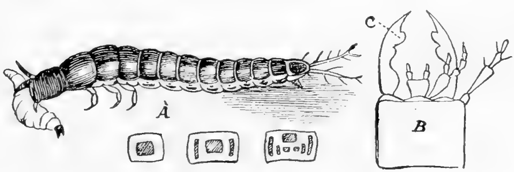

FIG. 142.—Larva of Murky Ground-beetle (*Harpalus caliginosus*). (After Riley.)

beak, and turkeys often feed upon this pest to a considerable extent.

Probably the most destructive insect-parasite of the larvæ is a Tachinid-fly known to science as *Lydella doryphoræ* Ril., which rather closely resembles the common house-fly, both in size and color. A single egg is laid on a potato-bug and from it hatches a small, footless maggot which burrows inside the bug. When the larva enters the earth, the effect of the maggot's work becomes apparent, and instead of transforming to a pupa and beetle, it

shrivels up and dies. But the maggot itself contracts into a hard, brown pupa, from which the fly eventually emerges. Thus in 1868, when first noted by Doctor C. V. Riley, he asserted that in Missouri fully ten per cent of the second brood and one-half of the third were destroyed by this parasite.

Many of our common ladybird-beetles and their larvæ check the pest by feeding upon the eggs. Several predaceous bugs are of value in destroying the larvæ, into which they thrust their short, powerful beaks, and then suck out the juices of the body, leaving only an empty skin. One or two of these closely resemble the common squash-bug (*Anasa tristis* De G.), but are really very dissimilar, and whereas the beaks of the predaceous forms are short and thick, as in Fig. 139*a*, those of plant-feeders, like the squash-bug, are long and slender, as in Fig. 139*c*.

Several species of ground-beetles are often found preying upon the larvæ and beetles, but, unlike the bugs, attack them by means of their powerful biting jaws. These beetles are also exceedingly beneficial in feeding upon many other injurious insects, and are among the farmers' best insect friends (Fig. 141).

Remedies.—As an artificial remedy for this pest, Paris green has long been proven to be both effectual and practical.

For small areas it may be used dry by mixing it with one hundred times its weight of dry flour, land-plaster, or air-slaked lime, and should be applied while the plants are still wet with dew, either by a perforated can, or, better, by one of the improved powder-guns such as Leggett's, by which two rows of plants may be powdered at once.

For larger areas a wet application will doubtless be found more satisfactory. For this purpose one pound of Paris green and one pound of quicklime to one hundred and fifty gallons of water will kill all the insects biting the foliage. While the vines are young, this may best be carried in a half barrel placed on wheels, and applied with a suitable pump and nozzle. But as the vines become larger and the field is more difficult to traverse, a knapsack-sprayer will be found advantageous.

Either arsenite of lime or arsenite of soda is as effective as Paris green and very much cheaper.

By observing the pest and spraying when needed, no fear need be had of losses from this insect, and if such policy were adopted by every one, it would be but a few years before we would be comparatively free from it.

Flea-beetles.

Among the worst insect pests with which potato-growers have had to contend in recent years are the small black beetles, which, from their power of making long, quick jumps, are known as flea-beetles.

Indeed, in the Rural New Yorker potato-contest, in 1888, it was reported that the variety "Rural Seedling No. 3 lost the day and was nearly a failure on account of the ravages of the common flea-beetle, *Epitrix cucumeris.*"

Several species are known to attack the potato, the two most common being the Cucumber Flea-beetle (*Epitrix cucumeris* Harris) and one which Prof. H. A. Garman has styled the Southern Potato Flea-beetle (*Epitrix fuscula*). The Tobacco Flea-beetle (*Epitrix parvula*) is not uncommonly found on the vines in sections where its habitual food-plant is also grown. All of these species are, how-

ever, essentially the same in habits and life-history, and fortunately the same remedies apply to all. Unfortunately, the complete life-cycle of these little insects has never been carefully determined, so that only a general outline can be given.

During the winter the beetles hibernate under leaves, rubbish, etc., and in the spring come forth and lay their eggs upon the roots of some of our common weeds, such as the horse-nettle, Jamestown weed, Desmodium, and various members of the Nightshade family, or *Solanaceæ*. Here the larvæ feed upon the small roots by mining in them, and transform to pupæ in small cells among the roots. From the pupæ the beetles emerge and, after becoming hardened, come forth to attack the foliage, which they most thoroughly riddle, a badly eaten leaf appearing almost as if it had been the target for a shotgun.

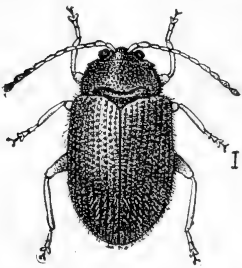

FIG. 143.—The Potato or Cucumber Flea-beetle (*Epitrix cucumeris*). Adult beetle, much enlarged. (After Chittenden, U. S. Dept. Agr.)

There are at least two, and possibly three, broods of most of the species, but I can find few accurate records concerning them.

Remedies.—Prof. C. M. Weed, of the New Hampshire Agricultural Experiment Station, has successfully used "a spray of lime-wash made by adding a pint or more of freshly slaked lime to two gallons of water, and then thoroughly mixing in about half a teaspoonful of Paris green."

The use of Bordeaux mixture as a repellant for flea-beetles was first tested and demonstrated to be effectual by

Prof. R. L. Jones, of the Vermont Experiment Station. Prepare the mixture in the usual manner, using six pounds of copper sulfate and four pounds of freshly slaked quicklime to fifty gallons of water, to which is added four ounces of Paris green, for the destruction of any other insect pests.

Spray this upon the vines so that they are well coated. Where this has been carefully tested it has been reported as a very successful repellant.

A few plants may be protected from flea-beetles by covering them with a frame composed of two crossed barrel-hoops on which is tacked some mosquito-netting or other material; but this method is hardly practicable upon large areas.

Blister-beetles (*Meloidæ*).

Long before we had made the acquaintance of the Colorado potato-bug, several species of blister-beetles frequently brought themselves into notice by their injuries, and, therefore, are now known as the "old-fashioned potato-bugs."

The name of "blister-beetles" has been bestowed upon them because of the blistering effect which they have upon the skin, they being nearly related to the Spanish Fly, used for that purpose, and are themselves brought to manufacturing chemists.

One of the most common of these is the Striped Blister-beetle, which has three yellow stripes upon its wing-covers, while the other two common forms are of a slate-black color.

Very often when these beetles congregate in great numbers they are a great nuisance, not only in the potato-

patch, but upon many other plants of the garden or truck-farm.

Unfortunately, they present to the farmer a very peculiar problem, for while the beetles are often exceedingly injurious, the larvæ are even more beneficial, in eating large quantities of grasshoppers' eggs.

Life-history.—The life of these insects is unique. The female lays a large number of eggs in a small cavity in the earth, and from these hatch some small, long-legged larvæ, which run about searching for the pod-like masses of grasshoppers' eggs, upon which they feed. As soon as the appetite of one of these little egg-hunters is appeased, he sheds his skin, and now being surrounded by food and no longer needing his long legs for running, in this next stage of his existence the legs are very short and rudimentary, and he remains almost immobile while feeding upon the rest of the eggs.

Thus, if their destructiveness be not too severe, it would not be good policy to destroy these beetles whose offspring are so beneficial.

Three-lined Leaf-beetle (*Lema trilineata* Oliv.).

Closely related to the Colorado Potato-beetle, and very similar to it in habits, is the Three-lined Leaf-beetle (*Lema trilineata* Oliv.). The eggs can scarcely be distinguished from those of that insect except by the fact that they are usually laid in rows along the midrib on the under side of the leaf, while those of the former are laid indiscriminately in bunches.

The larvæ, however, may be readily distinguished from all other insects attacking the potato by being covered with a disgusting mass of their own excrement.

There are two broods during the season, the larvæ of the first appearing in June, and that of the second in August; but the beetles of the second brood do not emerge until the following spring. In other respects the life-history is practically the same as that of the Colorado Potato-beetle. The beetle is of a pale yellow color, with three black stripes on its back, and in a general way

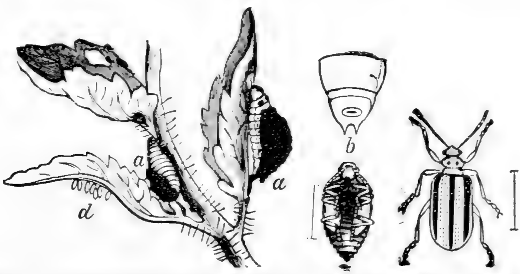

FIG. 144. — Three-lined Leaf-beetle (*Lema trilineata* Oliv.). *a*, larva; *b*, pupa; *d*, eggs; beetle at right. (After Riley.)

resembles the common striped Cucumber-beetle (*Diabrotica vittata* Fab.), though it is somewhat larger and the thorax is decidedly constricted.

In case it becomes necessary to destroy the Blister-beetles, both they and the Three-lined Leaf-beetle may be readily disposed of by applying Paris green or other arsenite as advised for the Colorado Potato-beetle.

CHAPTER XIII.

INSECTS INJURIOUS TO THE SUGAR-BEET.*

INJURING THE ROOT.

White Grubs and Wireworms. (See pages 44 and 48.)

FORTUNATELY for the sugar-beet farmer the worst insect enemies of that pest feed upon the tops, and very rarely do we hear of serious damage being done the roots. In the East most of the damage to the roots is done by those two familiar old farm-thieves, the white grub and the wireworm. As a general rule they will be found to be worse on lands previously in sod, which should therefore be avoided when known to be badly infested with either of these insects, as both are difficult to fight after they have once commenced doing noticeable injury.

As the wireworm-beetles — "click-beetles" — become mature in late summer, but remain in the pupal cell in a half-hardened condition over winter, much can be done toward destroying them by plowing late in the summer and keeping the land stirred for a month or so, in this way exposing the newly transformed tender beetles to the fall frosts.

---

* See Forbes and Hart, "The Economic Entomology of the Sugar-beet," Univ. Ill Agr. Exp. Sta., Bull. No. 60, Aug. 1900, for summary.

The Beet-aphis (*Pemphigus betæ* Doane).

This species was first described by Mr. W. R. Doane in 1900 and seems thus far to have been found only in Washington and Oregon. "Attention was first called to this pest," he says,* "in 1896, when it was found that a field of two or three acres of beets was generally infested, a strip of twenty-five to a hundred yards being so badly injured that the beets were nearly all soft and spongy, and the plants much smaller than the average.†

"It has been even more destructive in Oregon than in Washington, at least a thousand tons of beets having been destroyed by it in one year in a single valley devoted largely to beet-culture. Like very many other beet-insects, this species infests also several wild or useless plants.

"The smaller rootlets of the beet are first attacked by this aphis, and if it occurs in considerable numbers these are soon all destroyed, and the leaves thereupon soon wither, and the whole beet shrivels and becomes spongy. This wilting of the leaves will frequently, in fact, be the first thing to attract the attention of the beet-grower. The actual injury to the crop will, of course, depend largely upon the time when the attack of the aphis is made. If the plants are small they may be readily destroyed, while if they are practically full-grown the loss of the small rootlets will not materially affect them.

"No sexual generation of this aphis has as yet been discovered and no eggs have been seen, viviparous reproduction continuing throughout the year except when the cold

---

* Bull. No. 42, Wash. Agr. Exp. Sta.

† Forbes and Hart, Bull. No. 60, Univ. Ill. Agr. Exp. Sta., p. 507.

of the winter temporarily suspends the physiological activities of the species. The winged females, appearing from time to time during the summer and fall, serve to distribute the species generally, new colonies being started wherever these females find lodgment and food. In districts liable to injury by this insect it seems inadvisable

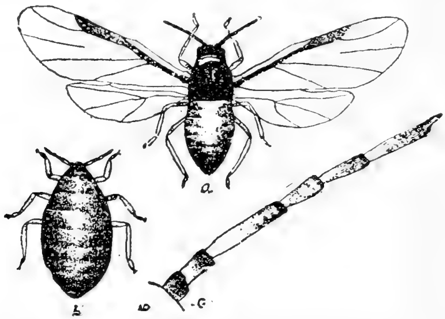

FIG. 145.—The Beet-aphis (*Pemphigus betæ* Doane). *a*, winged female; *b*, wingless female; *c*, antenna of winged female. (After Doane.)

that beets should be the first crop on new land, or that ground should be continued in beets or in any other root-crop after the pest has made its appearance in the field."

CUTTING THE TOPS.

Cutworms.

Like all similar crops, the sugar-beet is often subject to the midnight raids of the deadly Cutworms, and when present in any number they should be carefully guarded against while plants are young. Like the Web-worms, they are worse upon a sandy soil, and like the Wireworms, when the beets are on land previously in grass.

These well-known depredators are the larvæ of moths, which, from their habit of flying at night, are known as

Noctuidæ. The injurious species belong almost entirely to the genera *Mamestris*, *Hadena*, and *Agrotis*, and are sufficiently alike in their habits and life-history that the same methods may in general be applied to all. The worms are of dull brown, gray, or greenish hues, generally with longitudinal stripes, and often with oblique dashes.

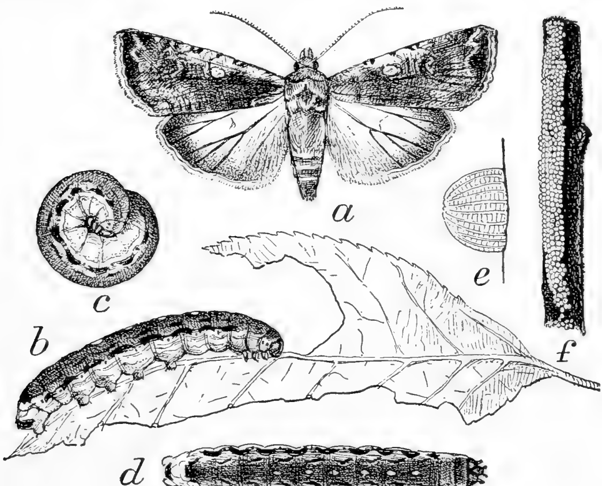

FIG. 146.—*Peridromia saucia.* *a*, adult; *b*, *c*, *d*, full-grown larvæ; *e*, *f*, eggs—all natural size except *e*, which is greatly enlarged. (After Howard, U. S. Dept. Agr.)

They are one and one-fourth to almost two inches in length and rather stout, but tapering. The head and segment back are reddish brown and horny. There are eight pairs of legs; the first three jointed and tapering, the last five (pro-legs) short and stout. Besides the beets they have been recorded as injuring almost every crop of the farm, orchard, and garden. Beets, turnips, and many of the garden crops are cut off at the neck just below the surface of the soil. Like the adults, the worms feed only at night,

excepting when a scarcity of food causes them to assemble and assume the marching habit of the army-worm during the day. For this reason their work often remains unnoticed until the damage is done, and no remedy can repair the loss. The characteristic mode of attack is to cut off the young plant at the surface of the ground and leisurely feed upon the leaves and stem, but several species

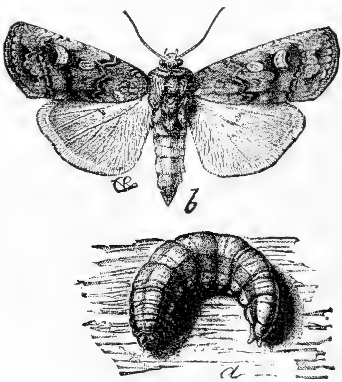

FIG. 147.—The Dark-sided Cutworm (*Agrotis messoria*). (After Riley.)

remain entirely under the soil, pulling the plant more or less into their subterranean retreat. The life-history of the various species of cutworms varies considerably, and has not been entirely ascertained for many of them, but whatever it may be they are always on hand, ready to nip the young plants as soon as set out.

Remedies.—All things considered, no remedy has as yet been devised which is more satisfactory or efficient than that of a mixture of bran or middlings and Paris green. This consists of mixing one pound of Paris green with forty of bran or middlings, barely moistening this with water into which has been stirred about two quarts of cheap molasses

or sorghum. The molasses gives the mash more or less of an odor, and renders it slightly more palatable. Do not have the mixture too wet or it will "cake." Apply this at the rate of a heaping tablespoonful about every three feet in the rows. Equally good results have been obtained by using thirty pounds of bran and middlings, dry, in equal parts, with one pound of Paris green, which is easily

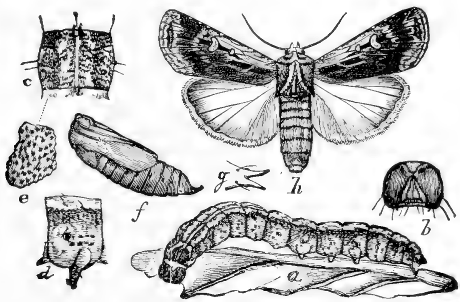

FIG. 148.—The Granulated Cutworm (*Agrotis annexa*). (After Riley.)

scattered by hand or by means of an onion-drill. When the worms are known to be present the mash should be applied two or three days before the young plants appear, in which case—having no other food—large numbers of the worms will be killed. If applied later, distribute the mash late in the afternoon, so that it will be fresh when the worms come out in the evening.

INJURING THE LEAVES.

Web-worms (*Loxostege spp.*).

Possibly the most destructive sugar-beet insects are the common Garden Web-worm (*Loxostege similalis* Gn.), and

the Sugar-beet Web-worm (*Loxostege stictialis* Linn.), larvæ of very closely allied moths of the family *Pyralidæ*. Until the summer of 1892 they had not been noted east of the Mississippi River, confining themselves to a region west of that to the Rockies and north of the Platte River. But in September of that year they destroyed fully fifty per cent of the tansy crop, which is largely grown for oil near Menon, Mich., and, since the extensive growing of the sugar-beet had hardly commenced at that time, it is safe to assume that with its more general culture in the East these two pests will accompany it.

The Garden Web-worm.

The greatest injury seems to be done by the second brood of caterpillars in July, and in Nebraska there are

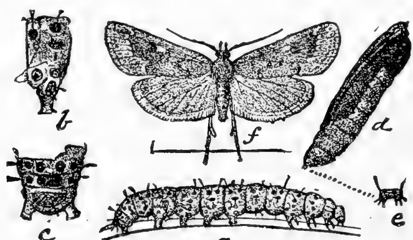

FIG. 149.—The Garden Web-worm (*Loxostege similalis* Gn.).

three broods during the season. When the fall brood has become full-grown it burrows into the earth, forms small cells, neatly lined with silk, and there lies dormant during the winter, transforming to pupæ the next May. The moths emerge in a week or ten days, and at once commence to lay eggs upon the leaves of the plants. They are pretty little moths, with a wing-expanse of about three-fourths

of an inch, quite variable in color, but generally an orange or reddish yellow, inclining to a shade of gray. Their characteristic dark and light markings are well shown in the figure. The eggs of the latter worm are a pale yellow, circular, somewhat flattened, and laid either singly or in rows of four or five. The young worms hatch in a few days, and often do serious injury by feeding upon the foliage of the plant, always spinning a light, silken web over them. Most of the feeding is done at night, but during the last stage they may be found during the day. This brood matures in about ten days after hatching, pupates, and the moths emerge early in July, giving rise to the destructive July brood of worms. The larvæ, or "web-worms," are about five-eighths of an inch long when full-grown, and, like the moth, are variable in color, being either a pale, dark, or even greenish yellow. They are distinctly marked by several rows of black spots, which are surrounded by a plain border, as in Fig. 149.

Remedies.—Deep plowing or thorough harrowing in the fall after the larvæ have entered the cocoons in the earth will destroy large numbers of them. When the worms appear in destructive numbers upon the foliage they may be controlled by a spray of Paris green or other arsenite, using one pound to 125 gallons of water, providing, of course, that the tops are not to be fed to stock. An under-spray nozzle should be used, so as to reach all parts of the plant in an effective manner. When present in large numbers and doing serious injury the worms can be more quickly killed by spraying with strong kerosene emulsion, but this will only kill those hit, and an arsenite should also be applied without delay.

The Beet Army-worm (*Laphygma flavimaculata* Harr.).

"This caterpillar, which replaces the Grass-worm (*L. frugiperda*—see page 84) in the Western States, differs from it by its more decidedly mottled ground-color, by a row of white dots at the lower margin of the lateral dark band, and by the yellower color of the light stripes. It is an interesting fact that while the preceding species was doing serious, unusual, and wide-extended injuries in the Eastern and Southern States (1899), the present one was similarly abundant in Colorado, where, besides destroying many kinds of weeds and grasses, it completely defoliated thousands of acres of sugar-beets. In some cases where the foliage of the beet did not furnish it sufficient food, the root was attacked and the upper surface was completely gnawed away. Late plantings of course suffered most severely, especially when surrounded by newly broken ground. The weeds most generally eaten were pigweed, saltweed, wild sunflower, and *cleome.* Potato-, pea-, and apple-leaves were also devoured. These injuries occurred about the middle of August, at which time the larvæ and pupæ were abundant, and a few moths laden with eggs were noticed."

This species evidently hibernates as a moth, and at least two broods of larvæ may be looked for each year, the first about June and the second in August. The species has been reported thus far from Colorado and California, but it doubtless has a more extended range in the mountain region of the far West.

"Prof. Gillette's field-experiments showed that it could

be destroyed by dusting or spraying arsenical poisons on the leaves."*

Plant-bugs.

The Tarnished Plant-bug (*Lygus pratensis*), False Chinch-bug (*Nysius angustatus*), and several of the common plant-bugs often become so numerous as to do considerable damage. When present in large numbers, a spray of kerosene emulsion or kerosene and water might

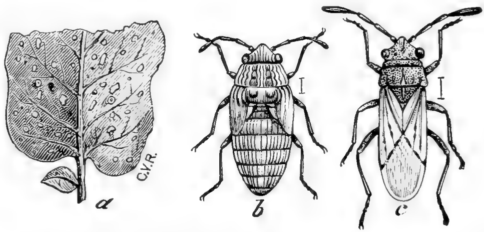

FIG. 150.—The False Chinch-bug (*Nysius angustatus*. (After Riley.)

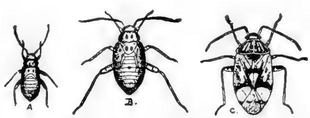

FIG. 151.—Tarnished Plant-bug (*Lygus pratensis* Linn.). *a*, young, first stage; *b*, young, third stage (×3); *c*, adult (×2)—all enlarged. (After Stedman.)

be used to great advantage. Recent experiments in New York show that the Tarnished Plant-bug can be driven from a field by dusting the rows with wood-ashes, being careful to work on the same side of each row and thus gradually driving them into the field adjoining.

* Forbes and Hart, l. c., facts derived from statements of Prof. C. P. Gillette.

Flea-beetles.

Several species of flea-beetles, chiefly *Systena tœniata, Systena hudsonias*, *Disonycha triangularis,* and *Phyllotreta vittata,* often do considerable injury by gnawing small holes in the upper and lower surfaces of the leaf, giving it an appearance as if affected by leaf-spot, or puncturing it full of small holes, and thus stunting the growth of the plant.

The Yellow-black Flea-beetle (*Disonycha xanthomelœna*).

This is one of the common beet-insects, both the larva and adults feeding upon the leaves. It may be distinguished among the Flea-beetles by its comparatively large size (its length about a quarter of an inch), by its metallic greenish-blue or black head and wing-covers, with the thorax uniformly pale yellowish above and black beneath, and the abdomen yellow beneath.

A much smaller, also very abundant, species whose injuries in spring frequently attract attention is the Pale-striped Flea-beetle (*Systena tœniata*). This is about an eighth of an inch in length, light yellowish brown in general color, with a broad, pale stripe down each wing-cover.

Most of the Flea-beetles are so similar in their general habits that they may be treated together, and the same remedies will be applicable for each species. The beetles hibernate over winter in woodlands, under rubbish, etc., and in the early spring deposit their eggs on the roots of common weeds of the family *Solonaceœ*, such as the Jamestown weed, horse-nettle, etc. On these the larvæ feed, mining the roots and stems of the plants. When full-

grown the larva transforms to a pupa inside a small earthen cell, and a week or ten days later the adult beetle emerges. The beetles may feed for a short time on the larval food-plant, but they soon desert it for some cultivated crop. A spray of Paris green and Bordeaux mixture will be found effectual in ridding the plants of these pests. It should be applied liberally and the spraying should be repeated, if necessary, after a heavy rain.

Clean Culture.—But there is one very simple method for securing immunity from all the pests so far mentioned, which should be practiced even were no insects present. There can be no doubt that the natural food-plants of all these insects, Web-worms, Flea-beetles, and Plant-bugs, consists of the common pigweeds, tumbleweeds, Jamestown weeds, etc. Thus, a field planted in beets, which has been idle and allowed to grow up in weeds, is always the most subject to insect attack, and it is always well to grow some crop prior to beets, and subsequently to pursue as much of a rotation as possible. Fields, fences, and roadsides should be kept well cleaned from these weeds, especially during the fall, after the crop is harvested, and with such precautions the few of these insects that are always present will do but slight injury.

Blister-beetles (*Meloidæ*).

Among those insects attacking the young sugar-beets and often doing considerable damage after they have become partly grown, few are more wide-spread or do more general injury than the Blister-beetles. They have been especially destructive in the northern Mississippi Valley, where they are usually worst after a period of unusual abundance of grasshoppers. Coming suddenly in a large

swarm, they settle in a field and thoroughly riddle the foliage with holes or strip it bare before going to another field.

One of the most common forms is the Striped Blister-beetle, or "old-fashioned potato-bug" (*Epicauta vittata*), which is shown in the illustration, together with the immature stages. The ash-gray Blister-beetle (*Macrobasis unicolor*) is also a common form, shown in Fig. 153. Three or four other forms are common throughout the country, but are especially numerous in the West, where grasshoppers are more abundant. The reason for this is apparent when we come to consider the life-history of the pest, for the Blister-beetles are not an unmixed evil.

Life-history.—In a small cavity in the earth the female beetle lays some four or five hundred eggs, these being

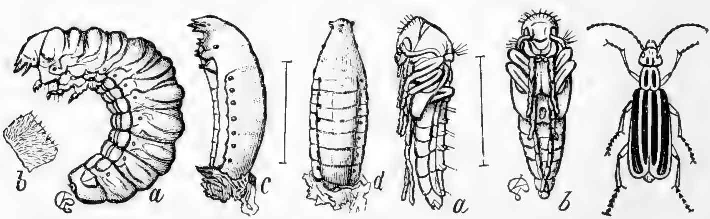

FIG. 152.—Striped Blister-beetle (*Epicauta vittata*). *a*, larva; *c*, *d*, hibernating stage of larva; adult beetle at right, and pupa at *a*, *b*. (After Riley.)

deposited from July to October. About ten days later the eggs hatch, and from them emerge some small but very active larvæ, with long legs, large heads, and strong jaws.

They at once commence running about in search of the pod-like masses of grasshoppers' eggs, and as soon as one is found the larva enters it and commences a hearty meal. As soon as his appetite has been somewhat satisfied he sheds his skin, and now being surrounded by food and no

longer needing his long running legs, they are changed for very short, aborted legs, and the larva is soft and sluggish. In another week a second molt takes place, after which the legs and even the mouth-parts are still more atrophied. After another molt and after consuming all the eggs in the pod, the larva now goes deeper in the soil, and inside a small oval cavity again sheds its skin, and hibernates over winter as a sort of semipupa. In the spring the larva

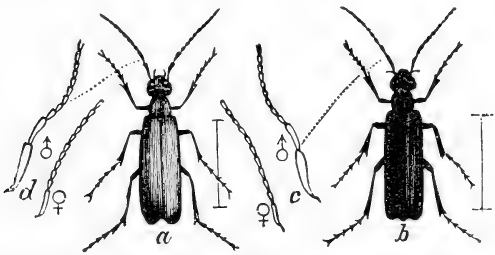

FIG. 153.—*a*, Ash-gray Blister-beetle (*Macrobasis unicolor; b, Epicauta pennsylvanica.* (After Riley.)

appears again much like the second stage, but does not eat much, and soon goes into the pupal stage from which emerges the adult beetle. Altogether the life-history is one of the most peculiar and complicated among insects. Thus the Blister-beetles are one of the most important factors in holding the grasshoppers in check.

Remedies.—However, when they swarm into the beet-fields, potato- or garden-patches, one cannot afford to allow them to consume one crop for the good they may do in saving another from still another insect scourge. "A bird in the hand is worth two in the bush," is equally true of insects. So be ready for them on their first appearance; give the plants a thorough spraying with Paris green, at the rate of one pound and one pound of lime to 125 gallons

of water, and when sprayed, it would be well to spray it with Bordeaux mixture, which will prevent various fungous diseases, and with which Paris green can be used much stronger without danger of burning the foliage; or it may be applied dry by mixing with from ten to twenty parts of flour or plaster, dusting it on in early morning, while the dew is still on the plants. Any other arsenical poison will prove equally effective, if used at the proper strength.

CHAPTER XIV.

INSECTS INJURIOUS TO THE HOP-PLANT.

INJURING THE STALK.

The Hop-plant Borer (*Hydrœcia immanis* Grt.).

THE Hop-plant Borer is sometimes the occasion of a considerable loss to the hop industry, Mr. Chas. R. Dodge having estimated upon the basis of the census of 1879 that it annually amounts to $600,000 in New York State alone. The moths have been taken from Ontario and New England south to the District of Columbia, and west to Wisconsin, and also from Colorado and Washington, but the larvæ have never become injurious in the hop-fields of the Pacific Coast. "It is probable that it is a northern form, and confined, as it seems to be, to a single food-plant, it will be found only where this plant is known to grow." *

Life-history.—Many of the moths emerge from the pupæ in the fall and hibernate over winter, while others do not transform till spring, passing the winter in the pupal stage, in a small cell in the ground near the roots of the plant which the larvæ have infested. The moths appear during May, and the females deposit their globular,

* "Some Insects Affecting the Hop-plant," L. O. Howard, Bull. No. 7, n. s., Div. Ent., U. S. Dept. Agr., p. 41.

yellowish-green eggs upon the tips of the hop-vines just as they begin to climb. "The egg hatches in a few days and produces a minute slender greenish larva, spotted with black, which immediately burrows into the vine just below the tip, and spends a part of its life in the vine at this point. The vine soon shows the effects of the insects'

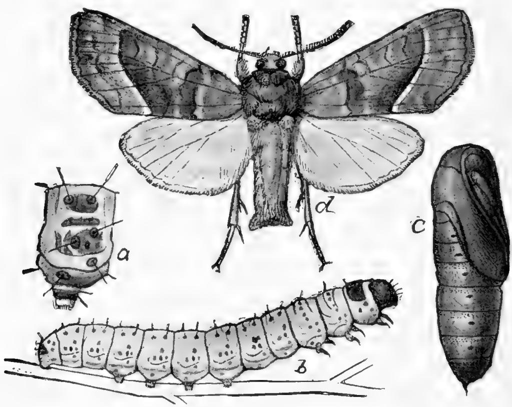

FIG. 154.—Hop-plant Borer (*Hydrœcia immanis* Grt.). *a*, enlarged segment of larva; *b*, larva; *c*, pupa; *d*, adult, natural size. (After Howard, U. S. Dept. Agr.)

work; instead of pointing upward, embracing the pole readily and growing rapidly, the tip points downward, will not climb, and almost entirely ceases growing. This appearance is called by growers a 'Muffle-head.' When the insect attains a length of about half an inch, or slightly less, it leaves the tip, drops to the ground, and entering the stem at the surface of the vine, feeds upward, interrupting the growth of the vine and lessening its vitality; the larva now changes color, and becomes a dirty-white, with a strong, deep reddish tint, with numerous black spots. The larva, now about an inch in length, and

still slender, burrows downward to the base of the vine at its juncture with the old stock, and eating its way out, completes its growth as a subterranean worker; it is in this state that it is best and most widely known as the hop 'grub,' and the ravages caused by it are most noted." *

The larvæ have mostly left the stems by the last of June and henceforth are mainly sap-feeders. Eating into the stem just below the surface of the ground and just above the old root, they rapidly grow fat upon the juices of the plant. These openings are gradually enlarged so that very often the stem is entirely severed from the root or is so slightly attached that the plant is badly stunted and yields few, if any, hops. The larvæ become full-grown from the middle to the 20th of July and are then "about two inches in length, fleshy, unwieldy, and very slow in their movements; they are of a dirty white color, speckled with fine, brownish elevated tubercles, each furnished with a single stout hair; the head is brownish and corneous, as is also the top of the first segment." (l.c.)

The larvæ now transform to pupæ in rough cells, close to the roots which they have infested, and the adult moths emerge during August or September, or the following spring. The adult moths are found to be most beautifully marked upon close examination, though not of a striking appearance at first sight. "The general color is a rosy brown, paler at the extremity of the wings. The darker central portion is shaded with dark velvety bronze and marked with two dull-yellow spots. The fore wings are divided into three areas by narrow oblique transverse lines,

---

* "Hop-insects," Dr. J. B. Smith, Bull. No. 4, o. s., Div. Ent. U. S. Dept. Agr.

edged outwardly with pink. The hind wings are paler in color, crossed in the middle by a slightly darker line." (Howard, l.c.)

Remedies.—Two points in the life-history of the insect afford opportunity for its control. The first of these is when the young larvæ are still in the tips and can easily be crushed by the fingers when tying the vines. "Muffle-heads" should always be picked off and destroyed.

Early in June when the larvæ have left the inside of the vines it is well to remove all the soil from the base of the vine, down to the junction with the old root. The larvæ, which will not feed above ground, will go to the old roots, to which they will do but little injury. The roots should be left thus exposed for about a week. A handful of mixture of coal and wood ashes or ammoniated phosphate should then be applied to each and the plants hilled high. The plant will now send out new rootlets from the main root, and is able to secure necessary nourishment through them.

INJURING THE LEAVES.

The Hop-louse (*Phorodon humuli* Schr.).

Like many another aphid the Hop-louse has a most interesting life-history, which has been fully ascertained in but recent years. During the winter the small oval black eggs may be found in the crevices and around the buds of the terminal twigs of plum-trees near infested hop-fields. From these hatch a generation of females, known as "stem-mothers," during the following spring. The lice of this generation differ in being stouter, with shorter legs and honey-tubes than those of any other generation. Three generations feed upon the plum, the third becoming

winged and at once flying to its favorite food in the hop-field.

Throughout the summer the lice are produced parthenogenetically, as are almost all plant-lice (see page 136). They "multiply with astonishing rapidity for from five to twelve generations, carrying us in point of time to the hop-picking season." "Each parthenogenetic female is capable of producing on an average one hundred young

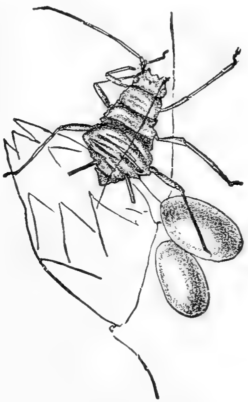

Fig. 155.—Winter Eggs of the Hop Plant-louse, and shriveled skin of the sexual female which laid them—enlarged. (After Riley, U.S. Dept. Agr.)

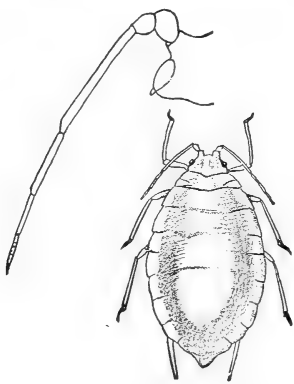

Fig. 156.—The Hop Plant-louse, stem-mother, with enlarged antennæ above. (After Riley, U. S. Dept. Agr.)

(the stem-mother probably being more prolific), at the rate of one to six, or an average of three per day, under favorable conditions. Each generation begins to breed about the eighth day after birth, so that the issue from a single individual easily runs up, in the course of the summer, to millions. The number of leaves (700 hills, each with two poles and two vines) to an acre of hops, as grown in the United States, will not, on the average, much exceed a

million before the period of blooming or burning; so that the issue from a single stem-mother may, under favoring circumstances, blight hundreds of acres in the course of two or three months." *

During September a brood of winged females are produced which fly back to the plum-trees and in the course

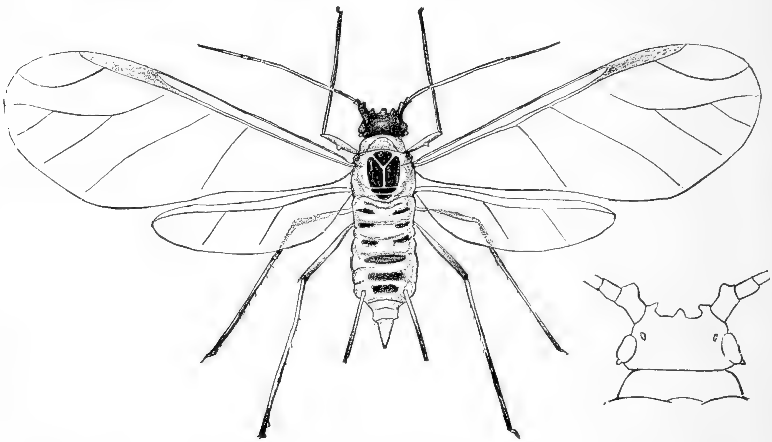

FIG. 157.—The Hop Plant-louse, third generation on plum—the generation which flies to the hop—enlarged; head below at right—still more enlarged. (After Riley, U. S. Dept. Agr.)

of a few days give birth to three or more young. These never become winged, but are the true sexual females which lay the winter eggs. The true winged males are developed during the latter part of the season and may be found pairing with the wingless females at that time, these being the only males during the year.

Remedies.—From a knowledge of the above-described life-history several methods of treatment have been secured. By spraying plum-trees neighboring the hop-

* Riley, "The Hop-louse," "Insect Life," Vol. I, p. 135.

yard and infested with lice while they are laying the eggs, during fall or in the spring, before the winged generation appears, with some substance which will destroy them, the pest may be prevented from getting a start the next season. Spraying the trees during the fall is best, because a stronger or more caustic solution can then be applied without danger of injury to the tree. A winter wash of one pound of concentrated lye to two gallons of water might be used as a spray to advantage in killing a large share of the eggs, but should not be applied after the buds commence to swell in the spring. To lessen the number of eggs all wild plum-trees in the neighboring woods should be destroyed. As soon as the crop is harvested, the hop-vines should be burned or thoroughly sprayed with kerosene emulsion, so as to kill off the males before they have been able to fertilize the females.

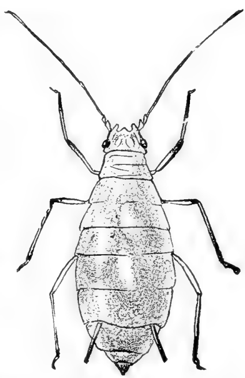

FIG. 158. — The Hop Plant-louse, true sexual female—enlarged. (After Riley, U. S. Dept. Agr.)

For spraying the plum-trees and hop-vines the following have given excellent satisfaction:

"*Kerosene Emulsion.*

Cheap kerosene	8 pints.
Water	4 "
Soap	½ pound.

"Dissolve the soap in the water and add (boiling hot) to the kerosene. Churn the mixture by means of a force-pump and spray-nozzle for 5 or 10 minutes. The emul-

sion, if perfect, forms a cream which thickens upon cooling, and should adhere without oiliness to the surface of glass. Dilute one part of the emulsion with 25 parts of water." Kerosene and water mechanically mixed ("Kerowater") would doubtless be equally effective applied at a strength of 15 or 20 per cent.

FIG. 159.—The Hop Plant-louse, male—enlarged. (After Riley, U. S. Dept. Agr.)

Fish-oil or whale-oil soap used at the rate of one pound to eight gallons of water will prove an effective spray against the lice. It can be purchased at from 3 to 5 cents per pound.

The Hop-vine Snout-moth (*Hypena humuli* Harr.).

The larvæ of the Hop-vine Snout-moth sometimes become very formidable pests in the hop-field, appearing

suddenly in large numbers and rapidly eating the foliage over a large area.

They are not known to have any other food-plant than the hop and hence are only found where that plant occurs, though specimens have been taken from almost all sections of the United States, southern Canada, and British Columbia.

Life-history.—It seems probable that the moths hibernate over winter, as they emerge in the fall, and lay eggs for the first brood early in the following May. The eggs are of a pale-green color, and are deposited upon the under surfaces of the leaves, sometimes several upon a single leaf. The larvæ emerging from them become mature late in June and early in July. When full-grown the larvæ are slightly less than one inch long, and "of a green color, marked with two longitudinal white lines down the back, a dark-green line in the middle between and an indistinct whitish line on each side of the body. The head is green, spotted with black piliferous dots, and similar dots occur on each segment, arranged in two transverse rows." *

Before pupating the larva spins a thin silken cocoon, either among the leaves, under the bark of the poles, or at or slightly under the surface of the ground, various observers having noted them in all of these positions. The pupal stage occupies about ten days, and the moths emerge from the cocoons early in July. Another brood follows with a similar life-history, the moths emerging late in August and in September and probably hibernating over winter.

---

* "Hop-insects," L. O. Howard, Bull. No. 7, n. s., Div. Ent., U. S. Dept. Agr.

The larvæ are known as "false loopers," on account of their bending the back slightly in creeping, which is due to their lacking the first pair of pro-legs.

Another species of the same genus (*Hypena rostralis*) affects hop-vines in Europe in the same manner and is very similar to the one above described.

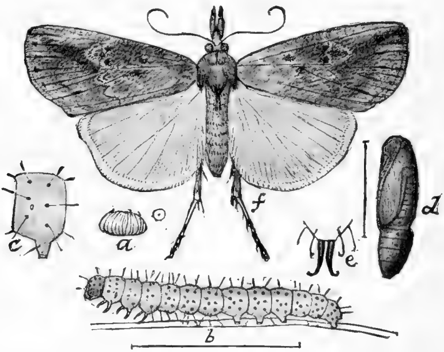

FIG. 160.—The Hop-vine Snout-moth (*Hypena humuli* Harr.). *a*, egg; *b*, larva; *c*, segment of same; *d*, pupa; *e*, cremaster of same; *f*, adult—*a*, *c*, *e*, greatly enlarged, others slightly enlarged. (After Howard, U. S. Dept. Agr.)

Remedies.—The larvæ can be controlled by the use of any arsenical spray, which should be applied while they are still young.

Hop-merchants.

The so-called "Hop-merchants" which here and there gleam from the vines are the chrysalids of two common butterflies, whose larvæ feed preferably upon hops. The chrysalids are normally marked with beautiful gold or silver spots, which sometimes become so diffused as to tinge the whole chrysalis. "An interesting superstition holds among hop-growers to the effect that when the

golden-spotted chrysalids are plentiful the crop will be good and the price high, while if the silver-spotted ones are plentiful and the golden-spotted ones are scarce the price will be low." (Howard, l.c.)

The Semicolon-butterfly (*Polygonia interrogationis* Godart).

The common names of these two butterflies indicate the most striking mark of distinction between them. *P. interrogationis* bears a silver mark like a semicolon or "interrogation" point upon the under side of the hind wings (Fig. 161), while *P. comma* has the same mark without the dot, which thus resembles a comma (Fig. 162).

The Semicolon-butterfly is common throughout the United States east of the Rockies, and especially in hop-growing regions. It hibernates over winter and is among the first butterflies to be seen in early spring, when it is often attracted to the flowing sap of newly cut trees. The eggs are laid late in May or early in June, usually upon the under surface of the leaves, of elm, blackberry, or nettle, either singly or in pendant columns of from two to eight. They hatch in from four to eleven days and the larvæ grow quite rapidly.

When full-grown the larva is an inch and a quarter long. The head is reddish black, somewhat bilobed, each lobe being tipped with a tubercle bearing five single, black-pointed spines, and covered with many small white and several blackish tubercles. The body is black, thickly covered with streaks and dots of yellowish white; the second segment is without spines, but with a row of yellowish tubercles in their place; the third segment has four branching spines, all black, with a spot of dark yellow at

their base; and on the fourth segment are four spines, as there are on all the others, excepting the terminal, which has two pairs, one posterior to the other. The spines are yellow, with blackish branches, excepting the terminal pair, which are black; and there is a row of reddish ones on each side. The under surface is yellowish gray, darker

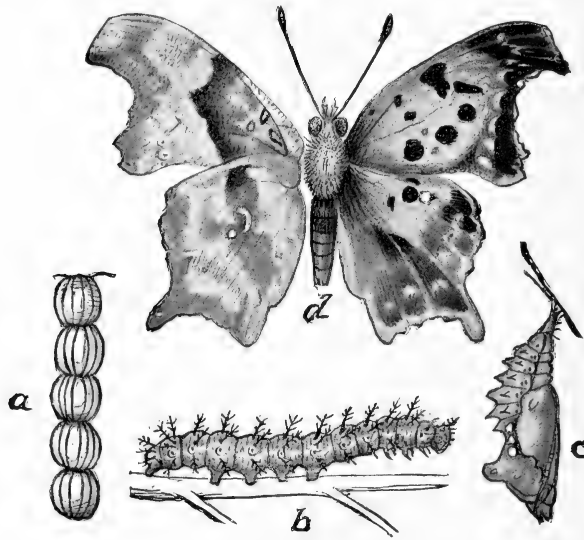

FIG. 161.—The Semicolon-butterfly (*Polygonia interrogationis*). *a*, egg-chain; *b*, larva; *c*, chrysalis; *d*, adult—all natural size except *a*, which is greatly enlarged. (After Howard, U. S. Dept. Agr.)

on the anterior segments, with a central line of blackish, and many small black dots. (Saunders.)

The chrysalis is ash-brown, with the head deeply notated, and with eight silvery spots on the back, this stage lasting from eleven to fourteen days and the butterflies emerging in July. These lay eggs for another brood late in July and throughout August, mainly upon the

hop-plants, where they are to be found. When the caterpillars of this brood are numerous they sometimes do considerable damage to the foliage, but both this and the following species are ordinarily prevented from becoming

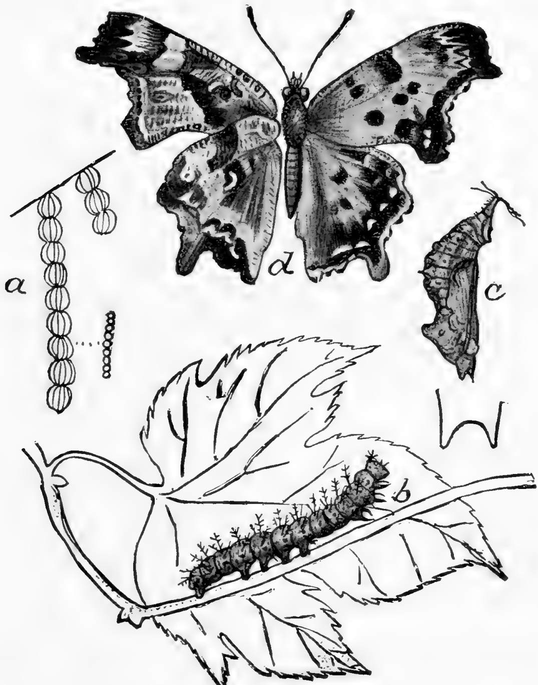

FIG. 162.—The Comma-butterfly (*Polygonia comma*). *a*, egg-chain, *b*, larva; *c*, chrysalis; *d*, adult—all natural size, except *a*, which is greatly enlarged. (After Howard, U. S. Dept. Agr.)

overnumerous by several parasites of the eggs and larvæ. Only when for some reason conditions are unfavorable to the development of its parasites does either species become especially abundant. In fact, Dr. J. B. Smith, who made extensive observations upon hop-insects in 1883, states

"that not one in ten of the insects ever attains the butterfly state."

The chrysalis stage of the second brood is somewhat longer than the first, sometimes lasting twenty-six days, and the butterflies emerge from the latter part of August until the end of October, and at once seek quarters in which to hibernate over winter.

Both this species and *P. comma* are dimorphic, the winter and summer forms differing in both sexes in both the upper and lower aspects of the wings. In the South, where from three to five broods occur in a season, both forms are usually found in the second and third broods, the summer form, *var. umbrosa*, gradually decreasing until all of the fourth brood are the hibernating winter form, *var. fabricii*.

The Comma-butterfly (*Polygonia comma* Harr.).

The Comma-butterfly is most common throughout the East from New England to North Carolina and Tennessee, though occasionally found as far west as Wisconsin, Iowa, Nebraska, and Texas.

Its life-history is practically the same as that of the species just described. The larvæ of the first brood sometimes seriously damage young elm-trees, which have been but recently reset, by eating them bare of the foliage. The winter form hibernates about a month earlier, being rarely seen in October. As a rule a similar dimorphism occurs, the hibernating form being known as *var. harrisii* and the summer form *var. dryas*, though the distinction is not as marked in this species.

The half-grown larva is black, with a yellowish stripe along the side from the third segment, and with yellow

stripes across the back, and spots of the same color at the base of the dorsal spines, which are yellow tipped with black. The mature caterpillar is white, mottled, or striped with gray or ashen, and with red spiracles. (W. H. Edwards.)

The butterflies of both species are of a rich brown color, marked with black and tipped with lilac above, and of a much darker purplish brown with the characteristic silver spots beneath, which are well indicated in the illustration.

Remedies.—Spraying with an arsenical will destroy the larvæ when such treatment becomes necessary.

CHAPTER XV.

INSECTICIDES.

Those insecticides sprayed or dusted are generally divisible into two classes: (1) poisons which kill by being eaten; and (2) oils or dusts which kill the insect by penetrating the skin or by clogging the breathing-pores. *Poisons* are used for insects such as grasshoppers, caterpillars, beetles, etc., which bite and chew their food (see page 12). *Contact insecticides* are used against insects, such as plant-lice, scale-insects, etc., which suck up the juices of the plant through a slender beak (see page 13) and which are not affected by poisons applied to the surface of the plant.

Gases are used against certain insects which cannot be effectively destroyed by sprays or other means. They kill by suffocation (see page 18).

Bordeaux mixture sometimes acts as a preventive against insects by rendering the food-plant distasteful to them.*

---

* Bordeau Mixture:

Copper sulphate (bluestone)............	4 pounds
Fresh lime (unslaked)..................	6 "
Water..................................	40 gallons

Dissolve the bluestone in a half barrel of water by hanging in a bag over night. Slake the lime and add to a half barrel of water. Pour the two half barrels of bluestone solution and lime into a third

POISONS. (FOR BITING INSECTS.)

Most of the poisons used as insecticides are composed of compounds of arsenic. Formerly only Paris green and London purple were used. Now several substitutes are cheaper and some more desirable. Therefore, where the word *arsenite* has been used above, any of the arsenites mentioned below may be used, except as qualified.

Remember that these poisons are all dangerous to human life. Keep them well labeled and locked up.

Arsenites.

Unless otherwise directed above, the arsenites may be either sprayed or dusted. Dusting is usually desirable on low-growing plants only and should be done in the early morning while damp with dew. When used dry the arsenite is usually mixed with land plaster or flour and is applied with a bellows, perforated can, or powder-gun.

When adding a dry arsenite to water for spraying, first mix it in a small quantity of water, so as to form a paste.

Paris Green.

Paris green	1 pound
Water	160–200 gallons
Lime	2 pounds

When used with Bordeaux mixture use 4 ounces of arsenite to 50 gallons of the mixture. Keep well stirred while spraying. 20 to 25 cents per pound.

---

empty barrel, stirring constantly. A "stock solution" of copper sulphate, in which 40 pounds is dissolved in 40 gallons of water, is convenient for extensive work. Four gallons should then be diluted with one-half barrel of water and mixed with lime as above.

London Purple.

Used in the same proportions as Paris green, but is much more caustic, its composition being variable, and should therefore have considerable more lime added.

Green Arsenoid.

"Is slightly superior to Paris green in composition and appears to be equally safe on foliage when applied at the ordinary strength. The powder is about a third lighter than Paris green, and remains correspondingly longer in suspension." Sold by manufacturers, Adler Color and Chemical Works, New York, at 15 cents per pound, or 13 cents in 100-pound kegs. Rather preferable to Paris green. Add plenty of lime.

Arsenite of Lead.

Least caustic of all the arsenites in its effect upon foliage. Remains in suspension and adheres to foliage better than Paris green. Is white in color. Sells at 15 to 18 cents per pound. Manufactured by Wm. H. Swift & Co., Boston, Mass. Can be made "by combining approximately 3 parts of the arsenite of soda with 7 parts of the acetate of lead (white sugar of lead) in water. These substances when pulverized unite readily and form a white precipitate, which is more easily kept suspended in water than any of the other poisons. At wholesale acetate of lead costs about 7¼ cents a pound, and the arsenite of soda, 5 cents. May be used at any strength from 3 to 15 pounds to 100 gallons of water without injury to foliage, and is much safer on delicate plants than any other arsenical."

"Disparene," manufactured by the Bowker Chemical

Co., Boston, Mass., is practically the same as arsenite of lead, and is much more adhesive than the other arsenites, this being due, we understand, to its containing glucose.

Arsenite of Lime.

"This has the threefold advantage of being (1) cheap, (2) the amount of arsenic is under perfect control, and (3) it does not burn the foliage. It is made by boiling together for 45 minutes:

White arsenic..................	1 pound
Fresh stone lime................	2 pounds
Water........................	1 gallon

"This may be kept in a tight vessel (marked 'Poison!') and used as desired. Thoroughly stir the material before using. For most insects, one quart of the above per barrel will be sufficient." It is insoluble in water and will not injure foliage at this strength. The cheapest arsenite and as effective as any.

Paragrene.

"Has equal insecticidal value with Paris green, is about as likely to burn the foliage and remains longer in suspension. We consider it an excellent substitute." Manufactured by Fred L. Lavenburg, New York, 13 cents per pound in 14-pound pails. Add 1 pound of lime per barrel.

Resin-lime Mixture.

Pulverized resin...........................	5 pounds
Concentrated lye	1 pound
Fish-oil, or any cheap animal-oil except tallow.	1 pint
Water....................................	5 gallons

Place oil, resin, and a gallon of water in an iron kettle and heat until resin is softened; add lye solution made as

for hard soap; stir thoroughly; add remainder of water and boil about two hours, or until the mixture will unite with cold water making a clear, amber-colored liquid. If the mixture has boiled away too much, add sufficient boiling water to make 5 gallons.

For use, dilute 1 gallon of this stock solution with 16 gallons of water, add 3 gallons of milk of lime, or whitewash, and $\frac{1}{4}$ pound Paris green or other arsenite.

Used on plants with a very smooth foliage.

Poisoned Bran Mash.

Wheat bran	40 pounds
Molasses (cheapest)	2 quarts
Arsenite (dry)	1 pound
Water	Enough to make a thick mash

Mix the arsenite with the dry bran. Stir the molasses into about a gallon of warm water, and pour over poisoned bran, stirring thoroughly, then adding enough water to make a stiff mash. Apply as near evening as possible, a heaping tablespoonful near each plant. Keep poultry out of fields thus treated. For cutworms apply a day or two before setting plants.

CONTACT INSECTICIDES. (FOR SUCKING INSECTS.)

Kerosene Emulsion.

Hard soap	$\frac{1}{2}$ pound
Boiling water	1 gallon
Kerosene	2 gallons

Dissolve the soap in the water, add the kerosene (away from the fire) and churn with a pump by pumping back and forth for 5 or 10 minutes. Dilute 4 to 15 times before applying. Dilute 10 to 12 times for plant-lice and soft-bodied bugs.

Kerosene-water Mixture (Kerowater).

Kerosene and water mixed mechanically may be used in all cases where kerosene emulsion is advised above. The water is placed in one tank, and the kerosene in another, the two being mixed in the spray-nozzle. Any desired percentage of kerosene may be used. Use 10 to 20 per cent for plant-lice. Generally much preferable to kerosene emulsion, but the latter is somewhat safer upon tender foliage. Can be applied only with a special pump having a kerosene attachment (same pump may be used for other purposes). Pumps manufactured by Deming Co., Salem, O., Goulds Co., Seneca Falls, N. Y., Spray Motor Co., London, Ont.

Tobacco.

In Water.—Place old stems and leaves in a tight vessel, cover with hot water, and allow to stand several hours. Dilute 3 to 5 times and apply.

Whale-oil Soap.

For plant-lice, 1 pound to 6 to 8 gallons of water. Costs 3 to 5 cents per pound. Manufactured by James Good, Philadelphia, Pa., Leggett & Bro., 301 Pearl St., New York, and W. H. Owen, Catawba Island, Ohio. Mr. Good is now making a soap containing tobacco which seems superior for soft-bodied larvæ.

Pyrethrum or Insect-powder.

Not poisonous to man in ordinary quantities, and therefore used against household pests, used either as powder or spray. Burn in room to destroy mosquitoes. Used in water at a rate of 1 ounce to 12 gallons, which should stand a day before using. Use in hot water for immediate application. Keep in tight cans—deteriorates with age.

Sulphur.

Apply at rate of 1 ounce to a gallon of water for red spiders and mites. Often used to rid poultry-houses of vermin. May be mixed with lard and rubbed on skin for lice that infest animals. Sprinkle in greenhouses, especially over steam or hot-water pipes.

GASES.

Carbon Bisulfide.

Used against insects affecting stored goods and grain. Is a clear volatile liquid, giving off fumes heavier than air. Sold in 25- to 100 pound lots at 10 to 12 cents per pound. May be thrown directly on wheat without injury to it, or may be placed in shallow dishes. For wheat in store apply 1 to 3 pounds to every 100 bushels. Make the enclosure as tight as possible, cover grain with blankets if necessary. Leave for twenty-four hours; over thirty-six hours will injure germinating qualities of grain. Do not inhale the fumes, or allow any light, cigar, or pipe around building, as gas is exceedingly explosive. For open enclosure use 1 pound to every 1000 cubic feet of space.

Hydrocyanic Acid Gas.

The best agent for the disinfection or fumigation of nursery-trees and plants, certain greenhouse insects, and pests of dwelling-houses, store-houses, mills, etc. Made by combining cyanide of potassium, sulphuric acid, and water. Diffuses quickly, is lighter than air, and a most deadly poison.*

---

* See "Fumigation Methods" by W. G. Johnson, Orange Judd Co.

INDEX.

(The number of the page giving complete description is in black-face type.)

SHORT-TITLE CATALOGUE

OF THE

PUBLICATIONS

OF

JOHN WILEY & SONS,

NEW YORK.

LONDON: CHAPMAN & HALL, LIMITED.

ARRANGED UNDER SUBJECTS.

Descriptive circulars sent on application.
Books marked with an asterisk are sold at *net* prices only.
All books are bound in cloth unless otherwise stated.

AGRICULTURE.

Armsby's Manual of Cattle-feeding....................12mo, $1 75
Downing's Fruits and Fruit-trees of America..............8vo, 5 00
Grotenfelt's Principles of Modern Dairy Practice. (Woll.)..12mo, 2 00
Kemp's Landscape Gardening........................12mo, 2 50
Maynard's Landscape Gardening as Applied to Home Decoration 12mo, 1 50
Stockbridge's Rocks and Soils..........................8vo, 2 50
Woll's Handbook for Farmers and Dairymen...........16mo, 1 50

ARCHITECTURE.

Baldwin's Steam Heating for Buildings................12mo, 2 50
Berg's Buildings and Structures of American Railroads....4to, 5 00
Birkmire's Planning and Construction of American Theatres.8vo, 3 00
" Architectural Iron and Steel..................8vo, 3 50
" Compound Riveted Girders as Applied in Buildings 8vo, 2 00
" Planning and Construction of High Office Buildings 8vo, 3 50
" Skeleton Construction in Buildings............8vo, 3 00
Briggs's Modern American School Buildings.............8vo, 4 00
Carpenter's Heating and Ventilating of Buildings........8vo, 3 00
Freitag's Architectural Engineering.....................8vo, 3 50
" Fireproofing of Steel Buildings.................8vo, 2 50
Gerhard's Guide to Sanitary House-inspection..........16mo, 1 00
" Theatre Fires and Panics..................12mo, 1 50
Hatfield's American House Carpenter..................8vo, 5 00
Holly's Carpenters' and Joiners' Handbook............18mo, 75
Kidder's Architect's and Builder's Pocket-book..16mo, morocco, 4 00
Merrill's Stones for Building and Decoration.............8vo, 5 00

Monckton's Stair-building....................................4to, 4 00
Patton's Practical Treatise on Foundations...............8vo, 5 00
Siebert and Biggin's Modern Stone-cutting and Masonry..8vo, 1 50
Wait's Engineering and Architectural Jurisprudence.....8vo, 6 00
Sheep, 6 50
" Law of Operations Preliminary to Construction in Engineering and Architecture...........................8vo, 5 00
Sheep, 5 50
" Law of Contracts....................................8vo, 3 00
Woodbury's Fire Protection of Mills......................8vo, 2 50
Worcester and Atkinson's Small Hospitals, Establishment and Maintenance, and Suggestions for Hospital Architecture, with Plans for a Small Hospital.................12mo, 1 25
The World's Columbian Exposition of 1893........Large 4to, 1 00

ARMY AND NAVY.

Bernadou's Smokeless Powder, Nitro-cellulose, and the Theory of the Cellulose Molecule.............................12mo, 2 50
* Bruff's Text-book of Ordnance and Gunnery.............8vo, 6 00
Chase's Screw Propellers and Marine Propulsion...........8vo, 3 00
Craig's Azimuth..4to, 3 50
Crehore and Squire's Polarizing Photo-chronograph......8vo, 3 00
Cronkhite's Gunnery for Non-commissioned Officers..24mo, mor., 2 00
* Davis's Elements of Law......................................8vo, 2 50
* " Treatise on the Military Law of United States...8vo, 7 00
* Sheep, 7 50
De Brack's Cavalry Outpost Duties. (Carr.)....24mo, morocco, 2 00
Dietz's Soldier's First Aid Handbook..........16mo, morocco, 1 25
* Dredge's Modern French Artillery..........4to, half morocco, 15 00
Durand's Resistance and Propulsion of Ships............8vo, 5 00
* Dyer's Handbook of Light Artillery....................12mo, 3 00
Eissler's Modern High Explosives..........................8vo, 4 00
* Fiebeger's Text-book on Field Fortification........Small 8vo, 2 00
* Hoff's Elementary Naval Tactics..........................8vo, 1 50
Ingalls's Handbook of Problems in Direct Fire............8vo, 4 00
* " Ballistic Tables......................................8vo, 1 50
Lyons's Treatise on Electromagnetic Phenomena.........8vo, 6 00
* Mahan's Permanent Fortifications. (Mercur's.).8vo, half mor. 7 50
Manual for Courts-martial........................16mo, morocco, 1 50
* Mercur's Attack of Fortified Places...................12mo, 2 00
* " Elements of the Art of War......................8vo, 4 00
Metcalfe's Cost of Manufactures—And the Administration of Workshops, Public and Private..............8vo, 5 00
" Ordnance and Gunnery...........................12mo, 5 00
Murray's Infantry Drill Regulations.............18mo, paper, 10
* Phelps's Practical Marine Surveying......................8vo, 2 50
Powell's Army Officer's Examiner..........................12mo, 4 00

Sharpe's Art of Subsisting Armies in War......18mo, morocco, 1 50
Walke's Lectures on Explosives.........................8vo, 4 00
* Wheeler's Siege Operations and Military Mining.........8vo, 2 00
Winthrop's Abridgment of Military Law................12mo, 2 50
Woodhull's Notes on Military Hygiene..................16mo, 1 50
Young's Simple Elements of Navigation........16mo, morocco, 1 00
Second Edition, Enlarged and Revised.......16mo, mor., 2 00

ASSAYING.

Fletcher's Practical Instructions in Quantitative Assaying with the Blowpipe...........................12mo, morocco, 1 50
Furman's Manual of Practical Assaying..................8vo, 3 00
Miller's Manual of Assaying..........................12mo, 1 00
O'Driscoll's Notes on the Treatment of Gold Ores........8vo, 2 00
Ricketts and Miller's Notes on Assaying................8vo, 3 00
Wilson's Cyanide Processes...........................12mo, 1 50
" Chlorination Process 12mo, 1 50

ASTRONOMY.

Craig's Azimuth.......................................4to, 3 50
Doolittle's Treatise on Practical Astronomy..............8vo, 4 00
Gore's Elements of Geodesy.............................8vo, 2 50
Hayford's Text-book of Geodetic Astronomy.............8vo, 3 00
Merriman's Elements of Precise Surveying and Geodesy....8vo, 2 50
* Michie and Harlow's Practical Astronomy..............8vo, 3 00
* White's Elements of Theoretical and Descriptive Astronomy. 12mo, 2 00

BOTANY.

Baldwin's Orchids of New England................Small 8vo, 1 50
Davenport's Statistical Methods, with Special Reference to Biological Variation.......................16mo, morocco, 1 25
Thomé and Bennett's Structural and Physiological Botany. 16mo, 2 25
Westermaier's Compendium of General Botany. (Schneider.) 8vo, 2 00

CHEMISTRY.

Adriance's Laboratory Calculations and Specific Gravity Tables, 12mo, 1 25
Allen's Tables for Iron Analysis........................8vo, 3 00
Arnold's Compendium of Chemistry. (Mandel.) (*In preparation.*)
Austen's Notes for Chemical Students...................12mo, 1 50
Bernadou's Smokeless Powder.—Nitro-cellulose, and Theory of the Cellulose Molecule..........................12mo, 2 50
Bolton's Quantitative Analysis.........................8vo, 1 50
Brush and Penfield's Manual of Determinative Mineralogy..8vo, 4 00
Classen's Quantitative Chemical Analysis by Electrolysis. (Herrick—Boltwood.) 8vo, 3 00

Cohn's Indicators and Test-papers........................12mo, 2 00
Craft's Short Course in Qualitative Chemical Analysis. (Schaeffer.) 12mo, 2 00
Drechsel's Chemical Reactions. (Merrill.)..............12mo, 1 25
Eissler's Modern High Explosives........................8vo, 4 00
Effront's Enzymes and their Applications. (Prescott.) (*In preparation.*)
Erdmann's Introduction to Chemical Preparations. (Dunlap.) 12mo, 1 25
Fletcher's Practical Instructions in Quantitative Assaying with the Blowpipe..........................12mo, morocco, 1 50
Fresenius's Manual of Qualitative Chemical Analysis. (Wells.) 8vo, 5 00
" System of Instruction in Quantitative Chemical Analysis. (Allen.) 8vo, 6 00
Fuertes's Water and Public Health.......................12mo, 1 50
Furman's Manual of Practical Assaying..................8vo, 3 00
Gill's Gas and Fuel Analysis for Engineers.............12mo, 1 25
Grotenfelt's Principles of Modern Dairy Practice. (Woll.)..12mo, 2 00
Hammarsten's Text-book of Physiological Chemistry. (Mandel.) 8vo, 4 00
Helm's Principles of Mathematical Chemistry. (Morgan.).12mo, 1 50
Holleman's Text-book of Inorganic Chemistry. (Cooper.) (*In preparation.*)
Hopkins's Oil-chemists' Handbook........................8vo, 3 00
Keep's Cast Iron. (*In preparation.*)
Ladd's Manual of Quantitative Chemical Analysis.......12mo, 1 00
Landauer's Spectrum Analysis. (Tingle.)................8vo, 3 00
Lassar-Cohn's Practical Urinary Analysis. (Lorenz.) (*In preparation.*)
Löb's Electrolysis and Electrosynthesis of Organic Compounds. (Lorenz.) 12mo, 1 00
Mandel's Handbook for Bio-chemical Laboratory........12mo, 1 50
Mason's Water-supply. (Considered Principally from a Sanitary Standpoint.)...8vo, 5 00
" Examination of Water. (Chemical and Bacteriological.) 12mo, 1 25
Meyer's Determination of Radicles in Carbon Compounds. (Tingle.) 12mo, 1 00
Miller's Manual of Assaying..................................12mo, 1 00
Mixter's Elementary Text-book of Chemistry............12mo, 1 50
Morgan's Outline of Theory of Solution and its Results...12mo, 1 00
" Elements of Physical Chemistry...............12mo, 2 00
Nichols's Water-supply. (Considered mainly from a Chemical and Sanitary Standpoint, 1883.)..........................8vo, 2 50
O'Brine's Laboratory Guide in Chemical Analysis.........8vo, 2 00
O'Driscoll's Notes on the Treatment of Gold Ores..........8vo, 2 00
Ost and Kolbeck's Text-book of Chemical Technology. (Lorenz—Bozart.) (*In preparation.*)

* Penfield's Notes on Determinative Mineralogy and Record of Mineral Tests .... 8vo, paper, 0 50
Pinner's Introduction to Organic Chemistry. (Austen.) ... 12mo, 1 50
Poole's Calorific Power of Fuels 8vo, 3 00
* Reisig's Guide to Piece-dyeing 8vo, 25 00
Richards and Woodman's Air, Water, and Food from a Sanitary Standpoint 8vo, 2 00
Richards's Cost of Living as Modified by Sanitary Science. 12mo, 1 00
" Cost of Food, a Study in Dietaries 12mo, 1 00
Ricketts and Russell's Skeleton Notes upon Inorganic Chemistry. (Part I.—Non-metallic Elements.) .. 8vo, morocco, 75
Ricketts and Miller's Notes on Assaying 8vo, 3 00
Rideal's Sewage and the Bacterial Purification of Sewage .. 8vo, 3 50
Ruddiman's Incompatibilities in Prescriptions 8vo, 2 00
Schimpf's Text-book of Volumetric Analysis 12mo, 2 50
Spencer's Handbook for Chemists of Beet-sugar Houses. 16mo, morocco, 3 00
" Handbook for Sugar Manufacturers and their Chemists .... 16mo, morocco, 2 00
Stockbridge's Rocks and Soils 8vo, 2 50
* Tillman's Elementary Lessons in Heat 8vo, 1 50
* " Descriptive General Chemistry 8vo, 3 00
Turneaure and Russell's Public Water-supplies 8vo, 5 00
Van Deventer's Physical Chemistry for Beginners. (Boltwood.) 12mo, 1 50
Walke's Lectures on Explosives 8vo, 4 00
Wells's Laboratory Guide in Qualitative Chemical Analysis. .. 8vo, 1 50
" Short Course in Inorganic Qualitative Chemical Analysis for Engineering Students 12mo, 1 50
Whipple's Microscopy of Drinking-water 8vo, 3 50
Wiechmann's Sugar Analysis .... Small 8vo, 2 50
" Lecture-notes on Theoretical Chemistry 12mo, 3 00
Wilson's Cyanide Processes 12mo, 1 50
" Chlorination Process 12mo, 1 50
Wulling's Elementary Course in Inorganic Pharmaceutical and Medical Chemistry 12mo, 2 00

CIVIL ENGINEERING.

BRIDGES AND ROOFS. HYDRAULICS. MATERIALS OF ENGINEERING. RAILWAY ENGINEERING.

Baker's Engineers' Surveying Instruments 12mo, 3 00
Bixby's Graphical Computing Table .... Paper, $19\frac{1}{2} \times 24\frac{1}{4}$ inches. 25
Davis's Elevation and Stadia Tables 8vo, 1 00
Folwell's Sewerage. (Designing and Maintenance.) 8vo, 3 00
Freitag's Architectural Engineering 8vo, 3 50

Goodhue's Municipal Improvements	12mo,	1 75
Goodrich's Economic Disposal of Towns' Refuse	8vo,	3 50
Gore's Elements of Geodesy	8vo,	2 50
Hayford's Text-book of Geodetic Astronomy	8vo,	3 00
Howe's Retaining-walls for Earth	12mo,	1 25
Johnson's Theory and Practice of Surveying	Small 8vo,	4 00
" Stadia and Earth-work Tables	8vo,	1 25
Kiersted's Sewage Disposal	12mo,	1 25
Mahan's Treatise on Civil Engineering. (1873.) (Wood.)	8vo,	5 00
* Mahan's Descriptive Geometry	8vo,	1 50
Merriman's Elements of Precise Surveying and Geodesy	8vo,	2 50
Merriman and Brooks's Handbook for Surveyors	16mo, mor.,	2 00
Merriman's Elements of Sanitary Engineering	8vo,	2 00
Nugent's Plane Surveying. (*In preparation.*)		
Ogden's Sewer Design	12mo,	2 00
Patton's Treatise on Civil Engineering	8vo, half leather,	7 50
Reed's Topographical Drawing and Sketching	4to,	5 00
Rideal's Sewage and the Bacterial Purification of Sewage	8vo,	3 50
Siebert and Biggin's Modern Stone-cutting and Masonry	8vo,	1 50
Smith's Manual of Topographical Drawing. (McMillan.)	8vo,	2 50
* Trautwine's Civil Engineer's Pocket-book	16mo, morocco,	5 00
Wait's Engineering and Architectural Jurisprudence	8vo,	6 00
	Sheep,	6 50
" Law of Operations Preliminary to Construction in Engineering and Architecture	8vo,	5 00
	Sheep,	5 50
" Law of Contracts	8vo,	3 00
Warren's Stereotomy—Problems in Stone-cutting	8vo,	2 50
Webb's Problems in the Use and Adjustment of Engineering Instruments	16mo, morocco,	1 25
* Wheeler's Elementary Course of Civil Engineering	8vo,	4 00
Wilson's Topographic Surveying	8vo,	3 50

BRIDGES AND ROOFS.

Boller's Practical Treatise on the Construction of Iron Highway Bridges	8vo,	2 00
* Boller's Thames River Bridge	4to, paper,	5 00
Burr's Course on the Stresses in Bridges and Roof Trusses, Arched Ribs, and Suspension Bridges	8vo,	3 50
Du Bois's Stresses in Framed Structures	Small 4to,	10 00
Foster's Treatise on Wooden Trestle Bridges	4to,	5 00
Fowler's Coffer-dam Process for Piers	8vo,	2 50
Greene's Roof Trusses	8vo,	1 25
" Bridge Trusses	8vo,	2 50
" Arches in Wood, Iron, and Stone	8vo,	2 50
Howe's Treatise on Arches	8vo,	4 00

Johnson, Bryan and Turneaure's Theory and Practice in the Designing of Modern Framed Structures......Small 4to, 10 00
Merriman and Jacoby's Text-book on Roofs and Bridges:
Part I.—Stresses in Simple Trusses....................8vo, 2 50
Part II.—Graphic Statics...............................8vo, 2 00
Part III.—Bridge Design. Fourth Ed. (*In preparation.*)..8vo, 2 50
Part IV.—Higher Structures.............................8vo, 2 50
Morison's Memphis Bridge..............................4to, 10 00
Waddell's De Pontibus, a Pocket Book for Bridge Engineers. 16mo, mor., 3 00
" Specifications for Steel Bridges.............12mo, 1 25
Wood's Treatise on the Theory of the Construction of Bridges and Roofs 8vo, 2 00
Wright's Designing of Draw-spans:
Part I.—Plate-girder Draws.............................8vo, 2 50
Part II.—Riveted-truss and Pin-connected Long-span Draws. 8vo, 2 50
Two parts in one volume................................8vo, 3 50

HYDRAULICS.

Bazin's Experiments upon the Contraction of the Liquid Vein Issuing from an Orifice. (Trautwine.)..............8vo, 2 00
Bovey's Treatise on Hydraulics...........................8vo, 5 00
Church's Mechanics of Engineering.......................8vo, 6 00
Coffin's Graphical Solution of Hydraulic Problems..16mo, mor., 2 50
Flather's Dynamometers, and the Measurement of Power.12mo, 3 00
Folwell's Water-supply Engineering......................8vo, 4 00
Frizell's Water-power....................................8vo, 5 00
Fuertes's Water and Public Health....................12mo, 1 50
" Water-filtration Works.......................12mo, 2 50
Ganguillet and Kutter's General Formula for the Uniform Flow of Water in Rivers and Other Channels. (Hering and Trautwine.)...............................8vo, 4 00
Hazen's Filtration of Public Water-supply................8vo, 3 00
Hazleurst's Towers and Tanks for Water-works...........8vo, 2 50
Herschel's 115 Experiments on the Carrying Capacity of Large, Riveted, Metal Conduits..........................8vo, 2 00
Mason's Water-supply. (Considered Principally from a Sanitary Standpoint.)......................................8vo, 5 00
Merriman's Treatise on Hydraulics.......................8vo, 4 00
* Michie's Elements of Analytical Mechanics.............8vo, 4 00
Schuyler's Reservoirs for Irrigation, Water-power, and Domestic Water-supply..............................Large 8vo, 5 00
Turneaure and Russell. Public Water-supplies............8vo, 5 00
Wegmann's Design and Construction of Dams.............4to, 5 00
" Water-supply of the City of New York from 1658 to 1895 ....4to, 10 00
Weisbach's Hydraulics and Hydraulic Motors. (Du Bois.)..8vo, 5 00
Wilson's Manual of Irrigation Engineering..........Small 8vo, 4 00
Wolff's Windmill as a Prime Mover.......................8vo, 3 00
Wood's Turbines..8vo, 2 50
" Elements of Analytical Mechanics..................8vo, 3 00

MATERIALS OF ENGINEERING.

Baker's Treatise on Masonry Construction.............8vo, 5 00
Black's United States Public Works..............Oblong 4to, 5 00
Bovey's Strength of Materials and Theory of Structures....8vo, 7 50

Burr's Elasticity and Resistance of the Materials of Engineering 8vo, 5 00
Byrne's Highway Construction............................8vo, 5 00
" Inspection of the Materials and Workmanship Employed in Construction......................16mo, 3 00
Church's Mechanics of Engineering......................8vo, 6 00
Du Bois's Mechanics of Engineering. Vol. I........Small 4to, 10 00
Johnson's Materials of Construction...............Large 8vo, 6 00
Keep's Cast Iron. (*In preparation.*)
Lanza's Applied Mechanics..............................8vo, 7 50
Martens's Handbook on Testing Materials. (Henning.)........
2 vols., 8vo, 7 50
Merrill's Stones for Building and Decoration...............8vo, 5 00
Merriman's Text-book on the Mechanics of Materials......8vo, 4 00
Merriman's Strength of Materials........................12mo, 1 00
Metcalf's Steel. A Manual for Steel-users...............12mo, 2 00
Patton's Practical Treatise on Foundations................8vo, 5 00
Rockwell's Roads and Pavements in France............12mo, 1 25
Smith's Wire: Its Use and Manufacture............Small 4to, 3 00
Spalding's Hydraulic Cement...........................12mo, 2 00
" Text-book on Roads and Pavements..........12mo, 2 00
Thurston's Materials of Engineering.............3 Parts, 8vo, 8 00
Part I.—Non-metallic Materials of Engineering and Metallurgy 8vo, 2 00
Part II.—Iron and Steel...................................8vo, 3 50
Part III.—A Treatise on Brasses, Bronzes and Other Alloys and Their Constituents...............................8vo, 2 50
Thurston's Text-book of the Materials of Construction.....8vo, 5 00
Tillson's Street Pavements and Paving Materials..........8vo, 4 00
Waddell's De Pontibus. (A Pocket-book for Bridge Engineers.)
16mo, morocco, 3 00
" Specifications for Steel Bridges................12mo, 1 25
Wood's Treatise on the Resistance of Materials, and an Appendix on the Preservation of Timber..........8vo, 2 00
" Elements of Analytical Mechanics................8vo, 3 00

RAILWAY ENGINEERING.

Berg's Buildings and Structures of American Railroads..4to, 5 00
Brooks's Handbook of Street Railroad Location..16mo, morocco, 1 50
Butts's Civil Engineer's Field-book............16mo, morocco, 2 50
Crandall's Transition Curve...................16mo, morocco, 1 50
" Railway and Other Earthwork Tables........8vo, 1 50
Dawson's Electric Railways and Tramways.Small 4to, half mor., 12 50
" "Engineering" and Electric Traction Pocket-book.
16mo, morocco, 4 00
Dredge's History of the Pennsylvania Railroad: (1879.).Paper, 5 00
* Drinker's Tunneling, Explosive Compounds, and Rock Drills.
4to, half morocco, 25 00
Fisher's Table of Cubic Yards.....................Cardboard, 25
Godwin's Railroad Engineers' Field-book and Explorers' Guide.
16mo, morocco, 2 50
Howard's Transition Curve Field-book.........16mo, morocco, 1 50
Hudson's Tables for Calculating the Cubic Contents of Excavations and Embankments..........................8vo, 1 00
Nagle's Field Manual for Railroad Engineers....16mo, morocco, 3 00
Philbrick's Field Manual for Engineers........16mo, morocco, 3 00
Pratt and Alden's Street-railway Road-bed................8vo, 2 00

Searles's Field Engineering....................16mo, morocco, 3 00
" Railroad Spiral....................16mo, morocco, 1 50
Taylor's Prismoidal Formulæ and Earthwork.............8vo, 1 50
* Trautwine's Method of Calculating the Cubic Contents of Excavations and Embankments by the Aid of Diagrams 8vo, 2 00
* " The Field Practice of Laying Out Circular Curves for Railroads..................12mo, morocco, 2 50
* " Cross-section Sheet.........................Paper, 25
Webb's Railroad Construction............................8vo, 4 00
Wellington's Economic Theory of the Location of Railways.. Small 8vo, 5 00

DRAWING.

Barr's Kinematics of Machinery..........................8vo, 2 50
* Bartlett's Mechanical Drawing..........................8vo, 3 00
Durley's Elementary Text-book of the Kinematics of Machines. (*In preparation.*)
Hill's Text-book on Shades and Shadows, and Perspective..8vo, 2 00
Jones's Machine Design:
Part I.—Kinematics of Machinery....................8vo, 1 50
Part II.—Form, Strength and Proportions of Parts......8vo, 3 00
MacCord's Elements of Descriptive Geometry.............8vo, 3 00
" Kinematics; or, Practical Mechanism..........8vo, 5 00
" Mechanical Drawing..............................4to, 4 00
" Velocity Diagrams...............................8vo, 1 50
* Mahan's Descriptive Geometry and Stone-cutting.......8vo, 1 50
Mahan's Industrial Drawing. (Thompson.)................8vo, 3 50
Reed's Topographical Drawing and Sketching.............4to, 5 00
Reid's Course in Mechanical Drawing....................8vo, 2 00
" Text-book of Mechanical Drawing and Elementary Machine Design.................................8vo, 3 00
Robinson's Principles of Mechanism.....................8vo, 3 00
Smith's Manual of Topographical Drawing. (McMillan.).8vo, 2 50
Warren's Elements of Plane and Solid Free-hand Geometrical Drawing 12mo, 1 00
" Drafting Instruments and Operations..........12mo, 1 25
" Manual of Elementary Projection Drawing....12mo, 1 50
" Manual of Elementary Problems in the Linear Perspective of Form and Shadow.............12mo, 1 00
" Plane Problems in Elementary Geometry.......12mo, 1 25
" Primary Geometry..............................12mo, 75
" Elements of Descriptive Geometry, Shadows, and Perspective 8vo, 3 50
" General Problems of Shades and Shadows.......8vo, 3 00
" Elements of Machine Construction and Drawing..8vo, 7 50
" Problems, Theorems, and Examples in Descriptive Geometry 8vo, 2 50
Weisbach's Kinematics and the Power of Transmission. (Herrmann and Klein.) 8vo, 5 00
Whelpley's Practical Instruction in the Art of Letter Engraving 12mo, 2 00
Wilson's Topographic Surveying..........................8vo, 3 50
Wilson's Free-hand Perspective..........................8vo, 2 50
Woolf's Elementary Course in Descriptive Geometry..Large 8vo, 3 00

ELECTRICITY AND PHYSICS.

Anthony and Brackett's Text-book of Physics. (Magie.) Small 8vo, 3 00
Anthony's Lecture-notes on the Theory of Electrical Measurments 12mo, 1 00
Benjamin's History of Electricity........8vo, 3 00
Benjamin's Voltaic Cell........8vo, 3 00
Classen's Qantitative Chemical Analysis by Electrolysis. Herrick and Boltwood.)........8vo, 3 00
Crehore and Squier's Polarizing Photo-chronograph......8vo, 3 00
Dawson's Electric Railways and Tramways..Small 4to, half mor., 12 50
Dawson's "Engineering" and Electric Traction Pocket-book. 16mo, morocco, 4 00
Flather's Dynamometers, and the Measurement of Power..12mo, 3 00
Gilbert's De Magnete. (Mottelay.)........8vo, 2 50
Holman's Precision of Measurements........8vo, 2 00
" Telescopic Mirror-scale Method, Adjustments, and Tests ....Large 8vo, 75
Landauer's Spectrum Analysis. (Tingle.)........8vo, 3 00
Le Chatelier's High-temperature Measurements. (Boudouard—Burgess.) 12mo, 3 00
Löb's Electrolysis and Electrosynthesis of Organic Compounds. (Lorenz.) 12mo, 1 00
Lyons's Treatise on Electromagnetic Phenomena........8vo, 6 00
* Michie. Elements of Wave Motion Relating to Sound and Light 8vo, 4 00
Niaudet's Elementary Treatise on Electric Batteries (Fishback.) 12mo, 2 50
* Parshall and Hobart's Electric Generators..Small 4to, half mor., 10 00
Thurston's Stationary Steam-engines........8vo, 2 50
* Tillman. Elementary Lessons in Heat........8vo, 1 50
Tory and Pitcher. Manual of Laboratory Physics..Small 8vo, 2 00

LAW.

* Davis. Elements of Law........8vo, 2 50
* " Treatise on the Military Law of United States..8vo, 7 00
* Sheep, 7 50
Manual for Courts-martial........16mo, morocco, 1 50
Wait's Engineering and Architectural Jurisprudence......8vo, 6 00
Sheep, 6 50
" Law of Operations Preliminary to Construction in Engineering and Architecture........8vo, 5 00
Sheep, 5 50
" Law of Contracts........8vo, 3 00
Winthrop's Abridgment of Military Law........12mo, 2 50

MANUFACTURES.

Beaumont's Woollen and Worsted Cloth Manufacture....12mo, 1 50
Bernadou's Smokeless Powder—Nitro-cellulose and Theory of the Cellulose Molecule........12mo, 2 50
Bolland's Iron Founder........12mo, cloth, 2 50
" "The Iron Founder" Supplement........12mo, 2 50
" Encyclopedia of Founding and Dictionary of Foundry Terms Used in the Practice of Moulding....12mo, 3 00
Eissler's Modern High Explosives........8vo, 4 00
Effront's Enzymes and their Applications. (Prescott.) (*In preparation.*)
Fitzgerald's Boston Machinist........18mo, 1 00

Ford's Boiler Making for Boiler Makers.............18mo, 1 00
Hopkins's Oil-chemists' Handbook..........................8vo, 3 00
Keep's Cast Iron. (*In preparation.*)
Metcalf's Steel. A Manual for Steel-users..............12mo, 2 00
Metcalf's Cost of Manufactures—And the Administration of Workshops, Public and Private...............8vo, 5 00
Meyer's Modern Locomotive Construction.................4to, 10 00
* Reisig's Guide to Piece-dyeing..........................8vo, 25 00
Smith's Press-working of Metals..........................8vo, 3 00
" Wire: Its Use and Manufacture...........Small 4to, 3 00
Spalding's Hydraulic Cement..............................12mo, 2 00
Spencer's Handbook for Chemists of Beet-sugar Houses. 16mo, morocco, 3 00
" Handbook for Sugar Manufacturers and their Chemists.............................16mo, morocco, 2 00
Thurston's Manual of Steam-boilers, their Designs, Construction and Operation.....................................8vo, 5 00
Walke's Lectures on Explosives..........................8vo, 4 00
West's American Foundry Practice......................12mo, 2 50
" Moulder's Text-book..............................12mo, 2 50
Wiechmann's Sugar Analysis......................Small 8vo, 2 50
Wolff's Windmill as a Prime Mover.......................8vo, 3 00
Woodbury's Fire Protection of Mills....................8vo, 2 50

MATHEMATICS.

Baker's Elliptic Functions.....................................8vo, 1 50
* Bass's Elements of Differential Calculus...............12mo, 4 00
Briggs's Elements of Plane Analytic Geometry..........12mo, 1 00
Chapman's Elementary Course in Theory of Equations...12mo, 1 50
Compton's Manual of Logarithmic Computations........12mo, 1 50
Davis's Introduction to the Logic of Algebra..............8vo, 1 50
Halsted's Elements of Geometry.........................8vo, 1 75
" Elementary Synthetic Geometry...............8vo, 1 50
Johnson's Three-place Logarithmic Tables: Vest-pocket size, pap., 15
100 copies for 5 00
Mounted on heavy cardboard, 8 × 10 inches, 25
10 copies for 2 00
" Elementary Treatise on the Integral Calculus. Small 8vo, 1 50
" Curve Tracing in Cartesian Co-ordinates......12mo, 1 00
" Treatise on Ordinary and Partial Differential Equations..........................Small 8vo, 3 50
" Theory of Errors and the Method of Least Squares...................................12mo, 1 50
* " Theoretical Mechanics..........................12mo, 3 00
* Ludlow and Bass. Elements of Trigonometry and Logarithmic and Other Tables...............................8vo, 3 00
" Trigonometry. Tables published separately..Each, 2 00
Merriman and Woodward. Higher Mathematics..........8vo, 5 00
Merriman's Method of Least Squares.....................8vo, 2 00
Rice and Johnson's Elementary Treatise on the Differential Calculus ....Small 8vo, 3 00
" Differential and Integral Calculus. 2 vols. in one....................Small 8vo, 2 50
Wood's Elements of Co-ordinate Geometry................8vo, 2 00
" Trigometry: Analytical, Plane, and Spherical....12mo, 1 00

MECHANICAL ENGINEERING.

MATERIALS OF ENGINEERING, STEAM ENGINES AND BOILERS.

Baldwin's Steam Heating for Buildings..................12mo, 2 50
Barr's Kinematics of Machinery..........................8vo, 2 50
* Bartlett's Mechanical Drawing..........................8vo, 3 00
Benjamin's Wrinkles and Recipes........................12mo, 2 00
Carpenter's Experimental Engineering....................8vo, 6 00
" Heating and Ventilating Buildings..........8vo, 3 00
Clerk's Gas and Oil Engine........................Small 8vo, 4 00
Cromwell's Treatise on Toothed Gearing..................12mo, 1 50
" Treatise on Belts and Pulleys...............12mo, 1 50
Durley's Elementary Text-book of the Kinematics of Machines. (*In preparation.*)
Flather's Dynamometers, and the Measurement of Power ..12mo, 3 00
" Rope Driving................................12mo, 2 00
Gill's Gas an Fuel Analysis for Engineers.............12mo, 1 25
Hall's Car Lubrication................................12mo, 1 00
Jones's Machine Design:
Part I.—Kinematics of Machinery......................8vo, 1 50
Part II.—Form, Strength and Proportions of Parts......8vo, 3 00
Kent's Mechanical Engineers' Pocket-book....16mo, morocco, 5 00
Kerr's Power and Power Transmission. (*In preparation.*)
MacCord's Kinematics; or, Practical Mechanism..........8vo, 5 00
" Mechanical Drawing............................4to, 4 00
" Velocity Diagrams.............................8vo, 1 50
Mahan's Industrial Drawing. (Thompson.)...............8vo, 3 50
Poole's Calorific Power of Fuels......................8vo, 3 00
Reid's Course in Mechanical Drawing...................8vo, 2 00
" Text-book of Mechanical Drawing and Elementary Machine Design..............................8vo, 3 00
Richards's Compressed Air............................12mo, 1 50
Robinson's Principles of Mechanism....................8vo, 3 00
Smith's Press-working of Metals.......................8vo, 3 00
Thurston's Treatise on Friction and Lost Work in Machinery and Mill Work..............................8vo, 3 00
" Animal as a Machine and Prime Motor and the Laws of Energetics.........................12mo, 1 00
Warren's Elements of Machine Construction and Drawing..8vo, 7 50
Weisbach's Kinematics and the Power of Transmission. (Herrmann—Klein.) 8vo, 5 00
" Machinery of Transmission and Governors. (Herrmann—Klein.) 8vo, 5 00
" Hydraulics and Hydraulic Motors. (Du Bois.) .8vo, 5 00
Wolff's Windmill as a Prime Mover.....................8vo, 3 00
Wood's Turbines.......................................8vo, 2 50

MATERIALS OF ENGINEERING.

Bovey's Strength of Materials and Theory of Structures..8vo, 7 50
Burr's Elasticity and Resistance of the Materials of Engineering 8vo, 5 00
Church's Mechanics of Engineering......................8vo, 6 00
Johnson's Materials of Construction.............Large 8vo, 6 00
Keep's Cast Iron. (*In preparation.*)
Lanza's Applied Mechanics.............................8vo, 7 50
Martens's Handbook on Testing Materials. (Henning.)....8vo, 7 50
Merriman's Text-book on the Mechanics of Materials....8vo, 4 00
" Strength of Materials.......................12mo, 1 00

Metcalf's Steel. A Manual for Steel-users............12mo, 2 00
Smith's Wire: Its Use and Manufacture............Small 4to, 3 00
Thurston's Materials of Engineering............3 vols., 8vo, 8 00
Part II.—Iron and Steel..........................8vo, 3 50
Part III.—A Treatise on Brasses, Bronzes and Other Alloys and their Constituents..........................8vo, 2 50
Thurston's Text-book of the Materials of Construction....8vo, 5 00
Wood's Treatise on the Resistance of Materials and an Appendix on the Preservation of Timber..........8vo, 2 00
" Elements of Analytical Mechanics...............8vo, 3 00

STEAM ENGINES AND BOILERS.

Carnot's Reflections on the Motive Power of Heat. (Thurston.) 12mo, 1 50
Dawson's "Engineering" and Electric Traction Pocket-book. 16mo, morocco, 4 00
Ford's Boiler Making for Boiler Makers...............18mo, 1 00
Hemenway's Indicator Practice and Steam-engine Economy. 12mo, 2 00
Hutton's Mechanical Engineering of Power Plants........8vo, 5 00
" Heat and Heat-engines.........................8vo, 5 00
Kent's Steam-boiler Economy...........................8vo, 4 00
Kneass's Practice and Theory of the Injector..............8vo, 1 50
MacCord's Slide-valves.................................8vo, 2 00
Meyer's Modern Locomotive Construction................4to, 10 00
Peabody's Manual of the Steam-engine Indicator.........12mo, 1 50
" Tables of the Properties of Saturated Steam and Other Vapors..............................8vo, 1 00
" Thermodynamics of the Steam-engine and Other Heat-engines.............................8vo, 5 00
" Valve-gears for Steam-engines...................8vo, 2 50
Peabody and Miller. Steam-boilers.....................8vo, 4 00
Pray's Twenty Years with the Indicator...........Large 8vo, 2 50
Pupin's Thermodynamics of Reversible Cycles in Gases and Saturated Vapors. (Osterberg.).................12mo, 1 25
Reagan's Locomotive Mechanism and Engineering......12mo, 2 00
Rontgen's Principles of Thermodynamics. (Du Bois.)....8vo, 5 00
Sinclair's Locomotive Engine Running and Management..12mo, 2 00
Smart's Handbook of Engineering Laboratory Practice..12mo, 2 50
Snow's Steam-boiler Practice...........................8vo, 3 00
Spangler's Valve-gears..................................8vo, 2 50
" Notes on Thermodynamics.................12mo, 1 00
Thurston's Handy Tables.................................8vo, 1 50
" Manual of the Steam-engine.........2 vols., 8vo, 10 00
Part I.—History, Structure, and Theory...............8vo, 6 00
Part II.—Design, Construction, and Operation..........8vo, 6 00
Thurston's Handbook of Engine and Boiler Trials, and the Use of the Indicator and the Prony Brake........8vo, 5 00
" Stationary Steam-engines....................8vo, 2 50
" Steam-boiler Explosions in Theory and in Practice..12mo, 1 50
" Manual of Steam-boilers, Their Designs, Construction, and Operation.........................8vo, 5 00
Weisbach's Heat, Steam, and Steam-engines. (Du Bois.)..8vo, 5 00
Whitham's Steam-engine Design.........................8vo, 5 00
Wilson's Treatise on Steam-boilers. (Flather.)..........16mo, 2 50
Wood's Thermodynamics, Heat Motors, and Refrigerating Machines..8vo, 4 00

MECHANICS AND MACHINERY.

Barr's Kinematics of Machinery........................8vo, 2 50
Bovey's Strength of Materials and Theory of Structures..8vo, 7 50
Chordal.—Extracts from Letters.........................12mo, 2 00
Church's Mechanics of Engineering.....................8vo, 6 00
" Notes and Examples in Mechanics.............8vo, 2 00
Compton's First Lessons in Metal-working..............12mo, 1 50
Compton and De Groodt. The Speed Lathe..............12mo, 1 50
Cromwell's Treatise on Toothed Gearing................12mo, 1 50
" Treatise on Belts and Pulleys...............12mo, 1 50
Dana's Text-book of Elementary Mechanics for the Use of Colleges and Schools...............................12mo, 1 50
Dingey's Machinery Pattern Making...................12mo, 2 00
Dredge's Record of the Transportation Exhibits Building of the World's Columbian Exposition of 1893.....4to, half mor., 5 00
Du Bois's Elementary Principles of Mechanics:
Vol. I.—Kinematics 8vo, 3 50
Vol. II.—Statics..8vo, 4 00
Vol. III.—Kinetics.....................................8vo, 3 50
Du Bois's Mechanics of Engineering. Vol. I.........Small 4to, 10 00
Durley's Elementary Text-book of the Kinematics of Machines. (*In preparation.*)
Fitzgerald's Boston Machinist..........................16mo, 1 00
Flather's Dynamometers, and the Measurement of Power.12mo, 3 00
" Rope Driving...................................12mo, 2 00
Hall's Car Lubrication...................................12mo, 1 00
Holly's Art of Saw Filing...............................18mo, 75
* Johnson's Theoretical Mechanics.....................12mo, 3 00
Jones's Machine Design:
Part I.—Kinematics of Machinery.....................8vo, 1 50
Part II.—Form, Strength and Proportions of Parts....8vo, 3 00
Kerr's Power and Power Transmission. (*In preparation.*)
Lanza's Applied Mechanics...............................8vo, 7 50
MacCord's Kinematics; or, Practical Mechanism..........8vo, 5 00
" Velocity Diagrams.............................8vo, 1 50
Merriman's Text-book on the Mechanics of Materials......8vo, 4 00
* Michie's Elements of Analytical Mechanics..............8vo, 4 00
Reagan's Locomotive Mechanism and Engineering.......12mo, 2 00
Reid's Course in Mechanical Drawing....................8vo, 2 00
" Text-book of Mechanical Drawing and Elementary Machine Design................................8vo, 3 00
Richards's Compressed Air...............................12mo, 1 50
Robinson's Principles of Mechanism.....................8vo, 3 00
Sinclair's Locomotive-engine Running and Management..12mo, 2 00
Smith's Press-working of Metals.........................8vo, 3 00
Thurston's Treatise on Friction and Lost Work in Machinery and Mill Work..............................8vo, 3 00
" Animal as a Machine and Prime Motor, and the Laws of Energetics.........................12mo, 1 00
Warren's Elements of Machine Construction and Drawing..8vo, 7 50
Weisbach's Kinematics and the Power of Transmission. (Herrman—Klein.) 8vo, 5 00
" Machinery of Transmission and Governors. (Herr-(man—Klein.) 8vo, 5 00
Wood's Elements of Analytical Mechanics...............8vo, 3 00
" Principles of Elementary Mechanics.............12mo, 1 25
" Turbines 8vo, 2 50
The World's Columbian Exposition of 1893.................4to, 1 00

METALLURGY.

Egleston's Metallurgy of Silver, Gold, and Mercury:
Vol. I.—Silver....................................8vo, 7 50
Vol. II.—Gold and Mercury.........................8vo, 7 50
Keep's Cast Iron. (*In preparation.*)
Kunhardt's Practice of Ore Dressing in Europe..........8vo, 1 50
Le Chatelier's High-temperature Measurements. (Boudouard—Burgess.) 12mo, 3 00
Metcalf's Steel. A Manual for Steel-users..............12mo, 2 00
Thurston's Materials of Engineering. In Three Parts......8vo, 8 00
Part II.—Iron and Steel................................8vo, 3 50
Part III.—A Treatise on Brasses, Bronzes and Other Alloys and Their Constituents...............................8vo, 2 50

MINERALOGY.

Barringer's Description of Minerals of Commercial Value. Oblong, morocco, 2 50
Boyd's Resources of Southwest Virginia................8vo, 3 00
" Map of Southwest Virginia........Pocket-book form, 2 00
Brush's Manual of Determinative Mineralogy. (Penfield.) .8vo, 4 00
Chester's Catalogue of Minerals..................8vo, paper, 1 00
Cloth, 1 25
" Dictionary of the Names of Minerals............8vo, 3 50
Dana's System of Mineralogy..........Large 8vo, half leather, 12 50
" First Appendix to Dana's New " System of Mineralogy." Large 8vo, 1 00
" Text-book of Mineralogy...........................8vo, 4 00
" Minerals and How to Study Them..............12mo, 1 50
" Catalogue of American Localities of Minerals. Large 8vo, 1 00
" Manual of Mineralogy and Petrography..........12mo, 2 00
Egleston's Catalogue of Minerals and Synonyms..........8vo, 2 50
Hussak's The Determination of Rock-forming Minerals. (Smith.) ....Small 8vo, 2 00
* Penfield's Notes on Determinative Mineralogy and Record of Mineral Tests...........................8vo, paper, 50
Rosenbusch's Microscopical Physiography of the Rock-making Minerals. (Idding's.)...............................8vo, 5 00
* Tillman's Text-book of Important Minerals and Rocks..8vo, 2 00
Williams's Manual of Lithology.........................8vo, 3 00

MINING.

Beard's Ventilation of Mines..........................12mo, 2 50
Boyd's Resources of Southwest Virginia................8vo, 3 00
" Map of Southwest Virginia........Pocket-book form, 2 00
* Drinker's Tunneling, Explosive Compounds, and Rock Drills...............................4to, half morocco, 25 00
Eissler's Modern High Explosives......................8vo, 4 00
Goodyear's Coal-mines of the Western Coast of the United States 12mo, 2 50
Ihlseng's Manual of Mining...........................8vo, 4 00
Kunhardt's Practice of Ore Dressing in Europe...........8vo, 1 50
O'Driscoll's Notes on the Treatment of Gold Ores..........8vo, 2 00
Sawyer's Accidents in Mines...........................8vo, 7 00
Walke's Lectures on Explosives.........................8vo, 4 00
Wilson's Cyanide Processes...........................12mo, 1 50
Wilson's Chlorination Process.........................12mo, 1 50

Wilson's Hydraulic and Placer Mining.................12mo, 2 00
Wilson's Treatise on Practical and Theoretical Mine Ventilation 12mo, 1 25

SANITARY SCIENCE.

Folwell's Sewerage. (Designing, Construction and Maintenance.) 8vo, 3 00
" Water-supply Engineering.........................8vo, 4 00
Fuertes's Water and Public Health.......................12mo, 1 50
" Water-filtration Works..........................12mo, 2 50
Gerhard's Guide to Sanitary House-inspection..........16mo, 1 00
Goodrich's Economical Disposal of Towns' Refuse...Demy 8vo, 3 50
Hazen's Filtration of Public Water-supplies...............8vo, 3 00
Kiersted's Sewage Disposal...............................12mo, 1 25
Mason's Water-supply. (Considered Principally from a Sanitary Standpoint..............................8vo, 5 00
" Examination of Water. (Chemical and Bacteriological.) 12mo, 1 25
Merriman's Elements of Sanitary Engineering............8vo, 2 00
Nichols's Water-supply. (Considered Mainly from a Chemical and Sanitary Standpoint.) (1883.) 8vo, 2 50
Ogden's Sewer Design......................................12mo, 2 00
Richards's Cost of Food. A Study in Dietaries...........12mo, 1 00
Richards and Woodman's Air, Water, and Food from a Sanitary Standpoint...................................8vo, 2 00
Richards's Cost of Living as Modified by Sanitary Science. 12mo, 1 00
Rideal's Sewage and Bacterial Purification of Sewage......8vo, 3 50
Turneaure and Russell's Public Water-supplies............8vo, 5 00
Whipple's Microscopy of Drinking-water..................8vo, 3 50
Woodhull's Notes on Military Hygiene.................16mo, 1 50

MISCELLANEOUS.

Barker's Deep-sea Soundings..............................8vo, 2 00
Emmons's Geological Guide-book of the Rocky Mountain Excursion of the International Congress of Geologists. Large 8vo, 1 50
Ferrel's Popular Treatise on the Winds..................8vo, 4 00
Haines's American Railway Management................12mo, 2 50
Mott's Composition, Digestibility, and Nutritive Value of Food. Mounted chart, 1 25
" Fallacy of the Present Theory of Sound..........16mo, 1 00
Ricketts's History of Rensselaer Polytechnic Institute, 1824–1894....................................Small 8vo, 3 00
Rotherham's Emphasised New Testament...........Large 8vo, 2 00
" Critical Emphasised New Testament.......12mo, 1 50
Steel's Treatise on the Diseases of the Dog................8vo, 3 50
Totten's Important Question in Metrology...............8vo, 2 50
The World's Columbian Exposition of 1893..............4to, 1 00
Worcester and Atkinson. Small Hospitals, Establishment and Maintenance, and Suggestions for Hospital Architecture, with Plans for a Small Hospital...................12mo, 1 25

HEBREW AND CHALDEE TEXT-BOOKS.

Green's Grammar of the Hebrew Language..............8vo, 3 00
" Elementary Hebrew Grammar.................12mo, 1 25
" Hebrew Chrestomathy..............................8vo, 2 00
Gesenius's Hebrew and Chaldee Lexicon to the Old Testament Scriptures. (Tregelles.)........Small 4to, half morocco, 5 00
Letteris's Hebrew Bible....................................8vo, 2 25